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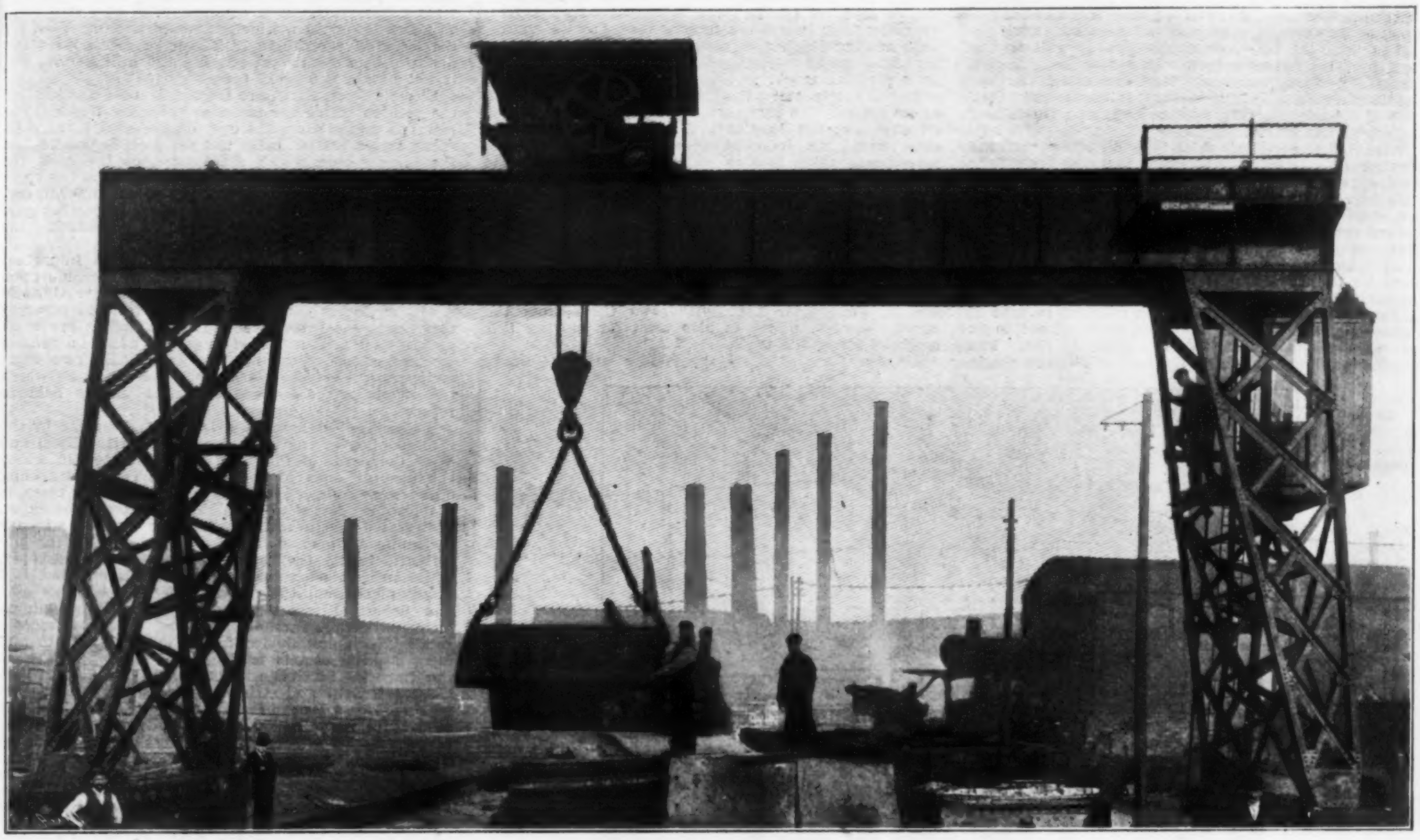
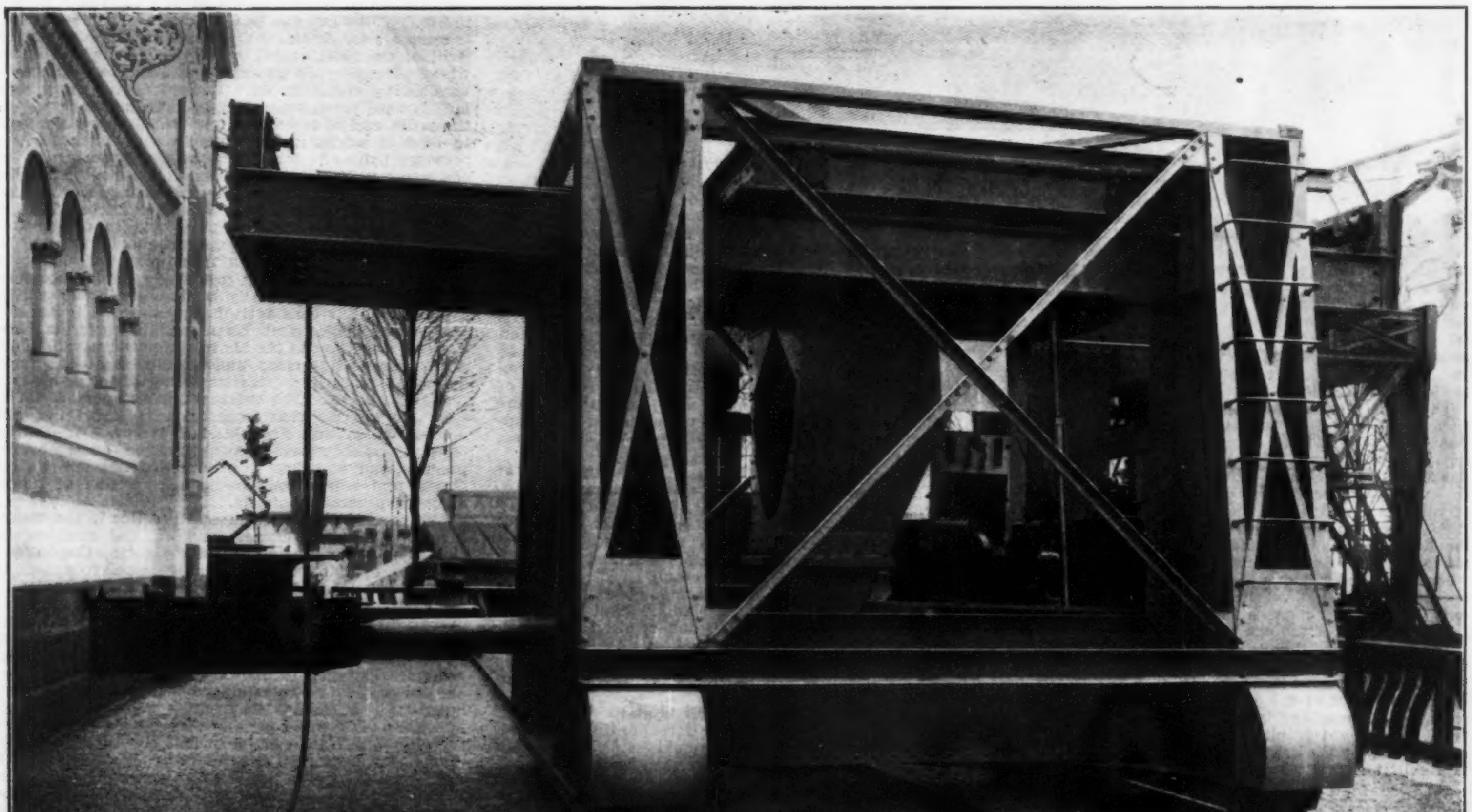


TWENTY-TON ELECTRIC CRANE.



ELECTRIC CHARGING APPLIANCE FOR OPEN-HEARTH FURNACE EXHIBITED AT DUESSELDORF.

ELECTRICAL MACHINERY OF GERMAN IRON AND STEEL WORKS.

ELECTRICALLY-OPERATED CHARGING MACHINES, HOISTS, HAULING, AND CONVEYING APPARATUS IN IRON AND STEEL WORKS.*

By FRANK C. PERKINS.

VARIOUS forms of charging appliances have been designed by European and American engineers to charge the blooms into the furnaces and afterward to transport the reheated blooms to the live rollers of the rolling mill, and in nearly every case electricity is the motive power employed, one man only being required to control and operate the apparatus.

In nearly all cases where the construction of the building and the roof allow it, the overhead traveling arrangement is preferable, as the rails for a charging car form somewhat of an obstacle on the floor. There are different constructions used according to the height and size of the blooms to be dealt with. The Junkerather Gewerkschaft and the Benrather Maschinenfabrik in Germany, as well as the Wellman-Seaver-Morgan Engineering Company of America, have installed both the traveling crane type as well as the high and low electric open-hearth furnace charging machines. The Benrather Maschinenfabrik Actien-Gesellschaft made an interesting exhibit of their high type of electric charging appliances at the Dusseldorf Industrial Exposition.

The Wellman electric high-type charging machine consists of a steel frame which is carried on four wheels, two of which are geared to an electric motor. This framework supports four steel columns on which are carried two steel beams. These beams project toward the furnace over the track on which stand the charging cars carrying the boxes. A carriage traverses these beams, and on the front end are hung the supports for the charging bar, which has trunnions about the middle of its length. The front half of the bar is made removable, so that it can be renewed in case of accident, and it is made T shaped at the front to fit into a recess on the back of the charging box. The operator's cab is attached to the back end of the charging box, and this cab is equipped with the controllers, a small motor for turning the bar, and a lever for throwing in the bar for locking the box to the charging bar. A motor is connected by a train of gearing to a shaft above, at each end of which is a crank, and the back end of the charging bar is given a vibratory motion through these cranks and connecting rods. Another electric motor for effecting the movement transversely is located on the forward end of the carriage, and this motor is geared by a single reduction direct to the forward axle.

There are three of the high type of Wellman electric open-hearth charging machines at the Pencoyd Iron Works, the size of the boxes being six feet, and a low-type electric charging machine at the works of the Sharon Steel Company, with the same size of box. In operating these electric charging machines, a train of cars loaded with the charging boxes is brought in front of the furnace, and the machine is moved by its longitudinal transverse motor until the end of the charging bar is exactly over the box to be charged, when the lifting motor is started, thus lifting the operator's cab and lowering the front end of the bar until the T head engages in the recess formed for it in the rear end of the charging box.

In the center of the charging bar is the locking bar, which is then pushed forward by the operator, locking the charging bar to the box. In case the box is not directly in front of the door through which it is to be charged, the machine is electrically moved along the track to the proper place, taking the whole train of cars with it, the machine thus being used as an electric shifting locomotive.

As soon as the proper place is reached, the lifting motor is reversed and the cab lowered, thus lifting the front end of the charging bar and with it the box. As the furnace door is lifted the box is run into the furnace by means of the cross transverse electric motor on the carriage, and the charging bar is then rotated by the motor in the cab, thus inverting the charging box and emptying the contents of the box onto the bed of the furnace. The box is then very rapidly withdrawn from the furnace, being inverted at the same time and placed on the car, and the same operation is repeated with each box which is to be charged.

The charging car inclined elevators of the Wellman type are operated by electric motors or by steam engines, and are used for transferring the charging box cars from the yard level to the charging platform level. It consists of a steel framework extending from the platform to the ground at an angle of about 25 degrees, and this framework supports an arrangement of sprocket wheels and gearing, which operates a special steel hauling chain provided with links having projections, which engage the axles of the charging cars and push the cars up the incline onto the charging floor level.

The Wellman electric ingot-handling machine, designed for the Standard Steel Works of Burham, Pa., is used for taking large octagonal-shaped ingots, weighing from half a ton to four tons, from a continuous heating furnace to the steam hammer and holding them under the hammer. This machine stands on a circular track, and as the furnace is at right angles to the hammer, the movement is simply turning on its center. The part carrying the tongs has an electrically operated longitudinal movement, the tongs also having an independent vertical and revolving movement, which is also made by means of electric power.

At the works of the Carnegie Steel Company at Pittsburg, there are in operation several electric heating, furnace charging machines of more than passing interest. One low type of electric heating, furnace charging machine at this plant picks up the ingots or slabs by means of electric motors controlled by a single operator, and places them in the heating furnaces, and at the proper time withdraws them from the same. Electric power is also used for moving this machine along the track.

Another form of charging machine at these works is the overhead or electric crane type. There are in operation four of the Wellman overhead heating, furnace charging machines which are equipped with electric motors for moving the crane transversely, also for moving the charging bar forward and back, to charge and withdraw the empty boxes, as well as another motor for giving a radial motion of the bar.

At the works of the Oberschlesischen Eisenbahn Bedarfs-Actien-Gesellschaft in Friedenshutte near Morganroth, there is an electrically operated charging crane with a span of 21.5 meters and a capacity of 3,000 kilogrammes. This machine was installed by the Duisburger Maschinenbau-Actien-Gesellschaft, formerly Bechem & Keetman, of Duisburg on the Rhine, Germany.

The electric bloom charging machine at the plant of the Differdingen Hochofen-Actien-Gesellschaft at Differdingen, Germany, was designed by the Wellman-Seaver-Morgan Engineering Company. It resembles somewhat their high type of open-hearth charging machine, being operated upon a track and not from an overhead electric traveling crane.

Electric capstans and hoists are employed frequently in and about iron and steel plants. The Jungrather Gewerkschaft have installed a number of electric hoisting winches for blast furnace bell tops, two motors being employed for this class of work. Electric power is most useful for this purpose, as the mechanism can be worked from any place desired.

The electrically-driven capstan is often employed in iron works to good advantage for shunting purposes. It executes this labor more quickly and easily than men or horses. Guide rolls for the traction rope are provided at convenient places, and one capstan electrically operated is sufficient to move the cars in both directions on the different tracks, and is also used to work the turntables.

An electric capstan for iron and steel works was exhibited at the Dusseldorf Exposition by the Benrather Maschinenfabrik, with inside controllers and motors having a normal capacity of 1,500 kilogrammes. The motors are of 12 horse power output, and the capstans have a normal hauling speed of 40 meters per minute.

At the Siemens-Martin steel foundry at the Belgian Ougree Blast Furnaces and Steel Works, the main hoist or winch has a capacity of 30 tons, and there are also six electric capstans for small loads installed in various parts of the works.

In America, as well as in Europe, the electric locomotive is used to a greater extent for hauling than the electric capstan. The Junkrather electric locomotives are constructed for standard and narrow gages with overhead wires, and also with accumulators, and the Siemens & Halske electric locomotives have been used very largely for hauling ladle cars, charging cars and cinder and slag cars.

At the Dusseldorf Exposition an interesting exhibit of electric locomotives for shunting purposes at iron and steel works was that of the Benrather Maschinenfabrik. Their electric shunting locomotive has a tractive power of 1,200 kilogrammes with a gage of 1,435 millimeters. It is equipped with two motors of 23 horse power each, which allow a traveling speed for the locomotive of 10 to 12 kilometers per hour. The distance between the wheels is 1,800 millimeters, and it weighs about 9 or 10 tons.

Electric locomotives are frequently used for hauling the cars on which are mounted the ingot molds. The metal is tapped from the open-hearth steel furnace directly into a casting ladle, and the steel is poured into the ingot molds, which are located on the cars, the casting ladles being tilted, and operated upon the track by electric power. In some cases, as at Differdingen, the ingot cars are moved by an electric adjusting gear which pulls the cars forward without necessitating the movement of the crane.

The electric ingot-stripping crane is an important device used when the casting is done in molds upon the cars. It is claimed by the Junkerather Gewerkschaft engineers that the molds last from 20 per cent to 30 per cent longer where ingot strippers are used, and there is a reduction of wages, as well as a greater working speed when they are employed. Two ingot strippers are usually placed over the tracks on which the ingots are delivered, and often one is held in reserve.

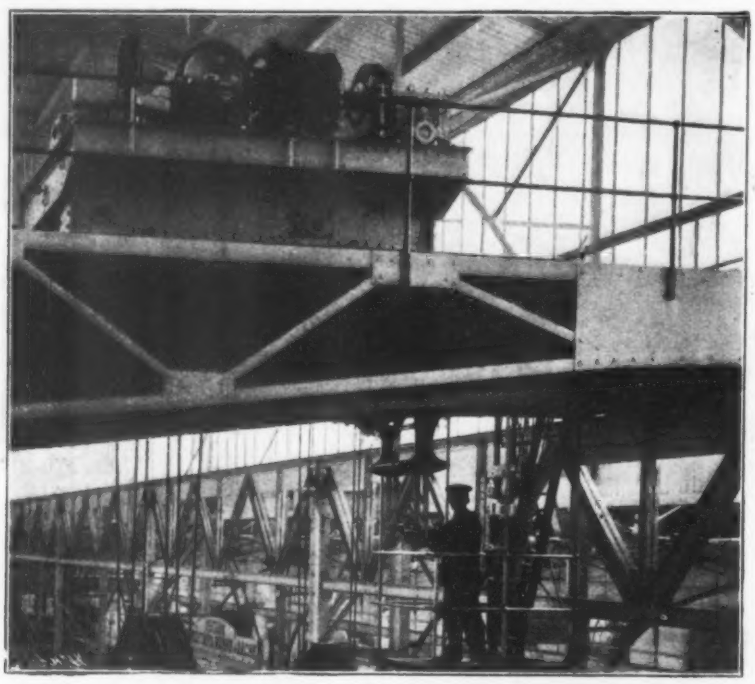
A special electric ingot stripper was designed by the Wellman-Seaver engineers for the American Steel and Wire Company, of Pittsburg and Worcester, in which the general lines of the electric overhead traveling crane were followed, on the trolley of which there is a telescopic device to strip the mold from the ingot. It is stated that in ordinary practice with a stationary hydraulic stripper it is necessary to bring the unstripped ingots in succession beneath the stripper, while with this arrangement the molds can be lifted at any place along the runway beneath the bridge span and deposited wherever convenient. The Wellman electric traveling crane with a vertical telescopic rotating gripping device for handling ingots to and from soaking pits is used at Worcester, and also at the Imperial Steel Works of Japan.

An interesting electrically-operated lever device is now used to a large extent for raising the lids of the soaking pits, and several rows of soaking pits can be served in this way with ease, doing away with the hydraulic apparatus for this purpose.

In connection with the 15-ton converter of the Junkerather Gewerkschaft, the car below the converter, designed to replace the converter bottom, is worked by hydraulic power, and in many instances electric power is not adapted to certain special work as steam and hydraulic power is. In the paper of R. M. Darlen, read before the Iron and Steel Institute at Dusseldorf, Germany, he says on the subject of "The Progress in Steel Works Practice in Germany": "The use of electric motors for driving rolling mills is at present very limited, and will probably only be adopted in cases where electricity is generated more cheaply than is possible by steam power. It is, however, now very largely used for driving the auxiliary machinery about the mills, and it is generally regarded as certain that in modern works it will entirely supersede the low-pressure hydraulic machinery which formerly was in common use." He then makes a statement which is not accepted by prominent engineers in America and Europe, in which he says: "Still, it must be admitted that the same precision of movement in cranes and hoisting gear is certainly not attainable by electric means, and for this reason many practical engineers of iron works still have a preference for low-pressure hydraulic power, especially as the machinery which gives it effect is constantly being improved." An editorial in the Electrical World and Engineer of New York, in referring to the above statement, says: "This strikes us as a serious understatement of the facts and as an unjustified criticism in regard to the electric crane and hoists. The swiftness, smoothness, and delicacy of electric crane operation is something not approached by any other kind of power. Mr. Darlen certainly cannot base his observation on American practice, and we refuse to believe that German electric cranes and hoists are lacking in precision of movement or general flexibility."

The best European continental practice in the manufacture of electric cranes for iron and steel works cannot be better illustrated than by noting the designs of those exhibited at the Dusseldorf Exposition of these industrial trades. In machinery hall, and also in the pavilion of Bechumer Verein, there are two electric overhead traveling cranes of 25,000 kilogrammes capacity, built by Ludwig Stuckenholz of Wetter a. d. Ruhr. The electric traveling cranes of 30,000 kilogrammes capacity exhibited by the Duisburger Maschinenbau A. G. are equipped with electric motors built by the Helios Electricitäts Actien-Gesellschaft of Cologne-Ehrenfeld, and one of the four large motor cranes in the machinery hall for iron and steel plants was shown by the Benrather Maschinenfabrik Actien Gesellschaft of Benrath near Dusseldorf. This overhead traveling crane has a capacity of 30 tons for each crab and a span of 21.34 meters. Each crab has not only a main hoisting gear for 60,000 pounds, but also an auxiliary hoisting gear for 10,000 pounds.

The Benrather four-motor electric crane is equipped with a 26 horse power motor, which allows a traveling speed of the crane of 100 meters per minute, while



HELIOS ELECTRIC TROLLEY FOR IRON AND STEEL PLANTS EXHIBITED AT DUESSELDORF.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

another motor of the same capacity gives a lifting speed of 2.5 meters per minute. The transversing speed is 20 meters per minute, and a 7 horse power motor is employed for this work. For operating the auxiliary hoisting gear of 5 tons capacity on each trolley there is a 26 horse power motor, which allows of an auxiliary lifting speed of 15 meters per minute.

In English iron and steel works, electrically-driven cranes are very largely used both in the yards and in the mills, those of Royce, Ltd., of Manchester, being constructed of 10 and 20 tons capacity for this class of work.

Practically all of the American plants are equipped with electric cranes for carrying the ladles, handling plates, rails and girders, as at the Duquesne Steel Works at Oliver, Pa., and the Martin plant of the Alabama Steel and Shipbuilding Company at Ensley, Pa., where 75-ton electric cranes are employed with additional crabs of 25 tons capacity.

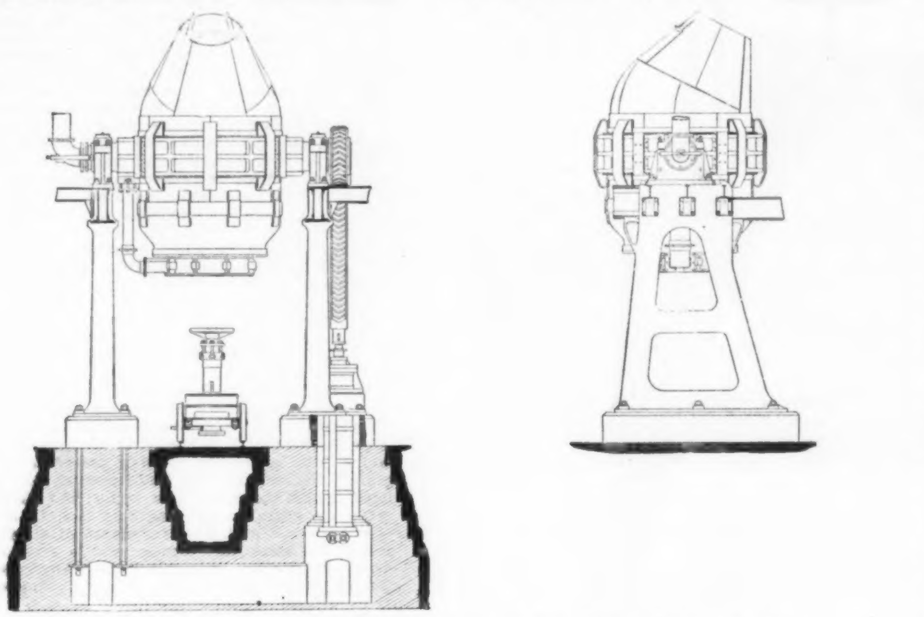
One of the most interesting electric cranes in use in the heavy plate-rolling mills are those which pick up the plates by electro-magnetic means and convey them where desired without the usual trouble of fastening the plates by chains, which is a very difficult method. A Wellman-Seaver electro-magnetic plate-handling crane is in operation at the works of the Oesterreichisch-Alpine-Montangesellschaft of Leoben, Austria. The heavy electric lifting magnets for these plate cranes are manufactured by the Electric Controller and Supply Company of Cleveland, Ohio, and similar cranes built by the Morgan Engineering Company are equipped with electro-magnetic plate-handling devices in use about the shears in the Otis Steel Company's works at Cleveland.

At the iron works of John Cockerill at Seraing, Belgium, the electric cranes are made use of in every department. These are Belgian cranes built by the Compagnie Internationale d'Electrique of Liege. There are three immense electric traveling cranes at the Philadelphia and Reading shops at Reading, Pa. They were constructed by the Niles-Bement-Pond Company, and are of the box girder type. One of the cranes has a span of 64 feet 10 inches and has a capacity of a quarter of a million pounds, and the other two have a span of 60 feet, with two trolleys having a total capacity of 60,000 pounds. The two 35-ton electric traveling cranes each have two trolleys of 17½ tons each, and the 120-ton crane has sustained a test load of 150 tons of steel rails. This crane is equipped with two 60-ton trolleys and has a 3-ton auxiliary hoist for use with light loads where the rapidity of work is an advantage. They are equipped with a specially designed electrical cutoff, which shuts off the current when the hook reaches its full height. A number of 10-ton electric cranes are also in operation at these shops.

Electricity is used as a motive power for nearly all ore, coke and coal handling and conveying apparatus in the principal steel plants in Europe and America. The electric conveying machinery at the works of the Oberschleisischen Eisenbahn-Bedarfs A. G. in Friedenshutte near Morganroth, Germany, was installed by Bechem & Keetman.

The great electrically-driven labor-saving devices in coke and ore handling were introduced first in the United States by the Brown Hoisting Company, Hoover & Mason, the Wellman-Seaver Engineering Company, and other prominent firms, and the unloading arrangements effect great savings in the handling of the material for iron and steel plants. The ore and coke are taken from the ships' holds in great quantities and conveyed to ore and coke bins by great traveling crane conveyors, and from these bins let into hopper-shaped trolleys, which are provided to run beneath the ore bins. A single electrically-driven hoisting machine often serves a number of furnaces, transferring the materials to the tops of the blast furnaces with the lowest cost for labor and the least possible handling.

The platform which is constructed beside the long row of furnaces carries the hopper to the hoist, and it is tipped into the hoisting skip, which is attached to a trolley with hoisting gear and runs on the tracks above the blast furnaces, automatically discharging the ore and coke into the furnaces desired. By the electric conveying apparatus of the Brown Hoisting Company or the Benrather Engineering Company from 75 to 200 tons of ore and coal can be handled per hour.



15-TON JUNKERATHER CONVERTER WITH HYDRAULIC CAR-HOIST TO REPLACE BOTTOM.

HISTORY OF THE PIANO AND ORGAN

According to a census report the piano is an invention about 200 years old. Like most other inventions, it is an evolution; it comes from the psaltry or harp by way of the harpsichord, the clavichord and the pianoforte or "piano e forte," which is "soft and loud." It was on the harpsichord that Beethoven, Mozart, Handel and the eminent composers of that day expressed their compositions. This instrument was like a harp inclosed in a box, with a mechanical device by which the manipulation of a keyboard plucked the wires. The resulting tone has been described as "a scratch with a sound at the end of it."

The inventor of the piano was a Florentine, one Cristofori, who lived about 1709. He conceived the idea of having the wires struck with a rebounding hammer instead of being scraped or plucked. A soft blow made the soft tone and a hard one a louder tone; hence the name. The soft pedal and damper was the invention of an Englishman named Broadwood, an Irishman conceived the idea of building it "upright," and Jonas Chickering of Boston worked out a lot of details and made the piano more like what it is to-day.

John Jacob Astor brought the first piano to the United States. This was in 1784. He had a lot of difficulty in keeping the wires from rusting during the ocean voyage, and when they got here the drier atmosphere of New York made the woodwork shrink and crack. This led to the making of pianos in the United States.

Philadelphia is the cradle of the American piano. The year before the Declaration of Independence John Behrent built a piano in that city. Ten years later New York started the industry, and that city now leads the world as a piano-manufacturing center. A great business depression in Europe in 1825 drove a lot of piano-makers to this country, and resulted in a wonderful stimulus to the business here.

The iron frame on which the wires of a piano are strung sustains a tension of thirty tons. The invention of this frame was what made Steinway and his instruments. He worked and studied for six years in all the principal foundries of Europe. Previous to his invention twelve tons had been about the limit of the frame tension.

A complete revolution in the style of pianos has taken place in this country since 1866. Up to that time nearly all were square pianos, now 97 per cent are uprights. Until 1876 there were two "schools of piano building." One was the Boston and the other the New York school. Each had its own theories as to frame and action, and clung to them with obstinacy.

In Chicago the piano industry is the growth of twenty years. During the last decade that city has forged to the front, and it now ranks second to New York, with an output valued at $5,802,718. New York's is a little more than double that. But in California, Massachusetts, Maryland and New York there has been a falling off of the amount of product during the last ten years. The returns of the last census show that the total value of the pianos made in this country in 1900 was $35,428,225, their number being 171,138.

To a barber is credited the invention of the organ. Two hundred years before Christ one Ctesibius, the proprietor of a hair-cutter's shop in Alexandria, while waiting for custom, thought of a scheme by which a row of levers could be used to open and shut the valves of a series of pipes. Before this some one had made a "pan-pipe," which was no more than a series of tubes of unequal length fastened side by side and attached to a wind-chest into which the operator blew. The pipes were closed with the fingers, one being left open at a time to emit the sound. Ctesibius's lever scheme did away with the fingering and made it possible to increase the size and number of the pipes.

The Alexandria barber fixed the levers into the shape of a rude keyboard, and in his instrument were all the essential features of the modern organ, namely, the pipes, the wind-chest and the keys. It was 870 years after this that organs began to be used in churches. Then the development began, at first chiefly in size. It is recalled that one instrument used in Winchester Cathedral in 951 had twenty-six pairs of bellows and required seventy men to fill it with wind. During all this time the keyboard remained practically the same—a row of not more than sixteen great levers, sometimes five or six inches wide, played by being struck with the clenched fist. The organist was known as an organ striker or "organorum pulsator." And it would be said that he "played with a delicate fist." It was not until the fourteenth century that the idea occurred to somebody to reduce the size of the keys so they might be played with the fingers. They increased the number of octaves to three, and then to four, with corresponding increases in the size and number of the pipes.

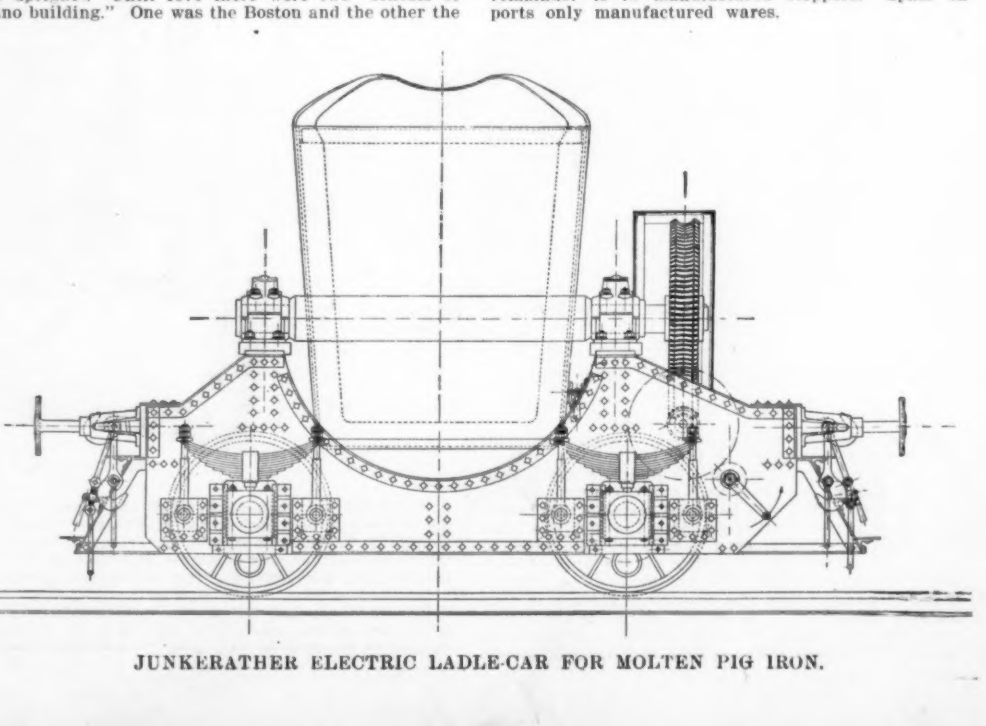
The first organ built in the United States was erected by John Clark in 1743 for the Episcopal Church at Salem, Mass. In 1805 William H. Goodrich of Boston began the building of organs that were a credit to the country. Boston still leads the industry, with Chicago a close second.

The reed organ is different from other organs in that the sound is made by the vibrations of a tongue of thin metal or wood inserted in the mouth of the pipe. This variation is a distinctly American invention, and Chicago is the home of the industry. The reed organ began as the accordion and developed into the melodeon, then into its present shape.

There are 129 organ factories in the United States with a capital of $5,000,000, employing 4,000 wage earners, and turning out an aggregate product each year valued at about $5,600,000.—Bradstreet's.

CORK PRODUCTION OF THE WORLD.

The Detail-Haendler states that the cork production of the world is narrowed down to Portugal, Spain, France, Italy, Tunis, Algeria and Morocco. The area over which the culture extends is about as follows: Portugal, 600,000 hectares; Spain, 300,000 ha.; Italy, 80,000 ha.; France and her African possessions, 661,000 ha., of which 426,000 are in Algiers and 82,000 in Tunis. The cork oak grows in forests in company mostly of firs and evergreen oaks, but in a part of Tunis there are forests consisting entirely of cork oaks. The bark of these Tunisian forests is said to be of an extraordinarily excellent kind. France, Great Britain, Germany and the United States receive about 85 per cent of the total production of cork. Germany, Russia and the United States have no prohibitory duties on importation of cork and cork goods, and admit the material free or with only a trifling impost. Great Britain also permits of the free entry of cork and draws most of its supplies from France, Spain and Portugal. The last named takes the chief place in cork production, producing nearly one half of the total growth of the bark—about 450,000 quartels out of the million produced. The greater part of this, perhaps three-fourths, is the crude bark, while the remainder is in manufactured stoppers. Spain exports only manufactured wares.



JUNKERATHER ELECTRIC LADLE-CAR FOR MOLTEN PIG IRON.

THE CHARRON, GIRARDOT, AND VOIGT GASOLINE AUTOMOBILE.

The experience obtained by Messrs. Charron, Girardot and Voigt in races, and the knowledge acquired by them as to the needs of purchasers, necessarily led quickly to the construction of a gasoline car containing every possible improvement. Judges of such matters are all astonished at the rapidity with which this firm, with the collaboration of M. Subra, head of the department of studies and superintendent of the works, succeeded in putting upon wheels a frame that has proved an entire success. This frame is, in its main features, of the type known as the "Panhard," in which the firm has rightly made no change in the form, but has merely aimed at improvement in details tending to extreme simplicity.

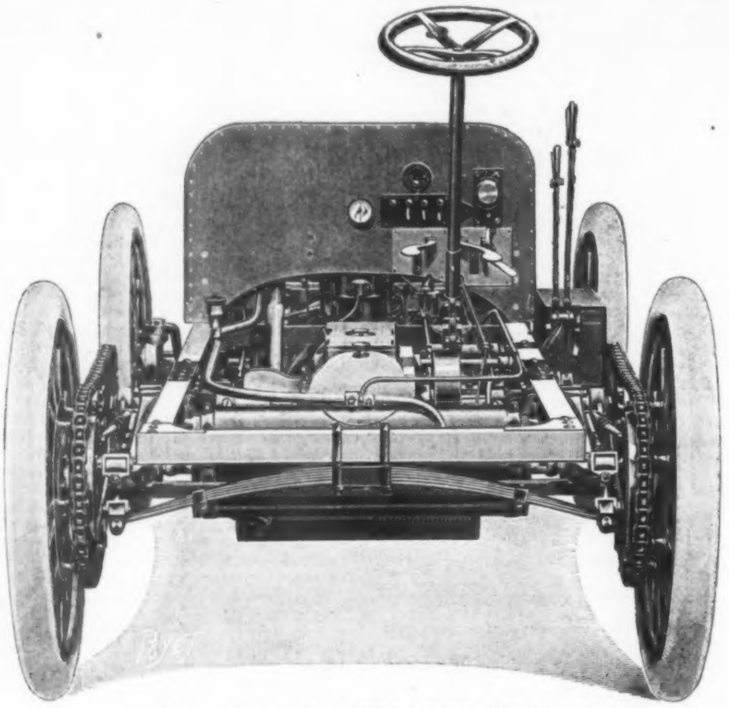


Fig. 1.—C. G. V. FRAME—REAR VIEW.

From the rear view of the "C. G. V." frame shown in Fig. 1, it will be seen that the steering hand wheel includes an interesting detail in the form of a support integrally formed with one of the arms for the purpose of attaching the horn.

The rear transverse spring is secured to the side springs by means of a quadruple joint so as to assure an exceptionally easy suspension. Upon the handsomely designed dashboard are admirably grouped the water gage, the four handles that regulate the admission of air, the circulation of hot water in the carbureter, the lead of the spark, and the admission of the gas. Above, is placed the make and break apparatus for the jump spark and, way to the right, the voltmeter that permits of verifying the energy remaining in the accumulators at any moment.

Fig. 2 shows the front axle with its double ball bearing steering knuckles, the radiator, and the motor. To the front springs there has been given a form such as to assure a maximum of lightness and rigidity.

The motor is shown in the front view, along with its carbureter to the left, the air intake of which projects at the upper part of the motor. The admission pipe is cleverly concealed, and ends above the motor at the movable coupling pipe designed to lead the explosive mixture to each cylinder. As for the pipe, which is shown in front of the motor, and which makes its exit at the level of the explosion chamber, that is designed for the circulation of the water for heating the carbureter.

Taking a side view of the frame (Fig. 3), the simplicity of its parts is noticeable, as well as the wheels of uniform size, and the wide wheel base. The motor is no longer concealed by an entangled mass of pipes, rods, and wires, badly placed and obliging the owner to dismount everything in order to tighten up or change some piece or other.

Finally, a view of the frame from the left (Fig. 4), shows the ingenious arrangement of the governor, inlet, and exhaust pipes, as well as the location of the water pump, which is actuated by a chain.

The filling plug is concealed in the front floor. The carriages recently sent out from the Puteaux works have a plug of special form which dispenses with the necessity of carrying a funnel. For filling the carriage with water, it suffices to raise a trap in the floor.—La Locomotion.

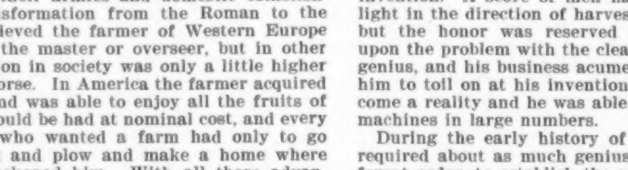


Fig. 2.—C. G. V. FRAME—FRONT VIEW.

THE HARVESTING MACHINE INDUSTRY.

By R. L. Ardrey.

Harvesting machines have exerted a most profound influence upon the affairs of men in the past century. A man can only produce as much wheat as he can reap and the harvest season is very short, nature allowing but a few days in which her most precious and beneficent crop may be gathered. With the sickle, a man could reap and bind perhaps ½ acre per day; with the cradle, 1 to 2 acres, allowing time for the work of binding. The twine binder reaps and binds 15 to 20 acres in a day, and the man who operates it rides on a comfortably spring seat. Under the *régime* of the sickle, nearly all the productive labor of wheat growing nations was absorbed in agriculture; and the development of great manufacturing industries was impossible for lack of labor and for lack of customers. An important exception might be noted in England, where the weaving industry had been developed on an extensive scale, but this was possible because in England wheat produces twice as much to the acre as the average yield of other countries, and hence less labor was required to provide bread for the English people and more was available for other occupations. In the United States nearly 80 per cent. of our population lived on the farm in 1840 and we had not yet emerged from the log cabin stage of our nation's history.

Until a comparatively recent period agriculture was the occupation of slaves. It was only by slave labor that the ruling classes in ancient empires were able to obtain bread for their armies and domestic establishments. The transformation from the Roman to the feudal system relieved the farmer of Western Europe from the lash of the master or overseer, but in other respects his position in society was only a little higher than that of the horse. In America the farmer acquired full civil rights and was able to enjoy all the fruits of his labor. Land could be had at nominal cost, and every industrious man who wanted a farm had only to go forth with his ax and plow and make a home where the virgin soil beckoned him. With all these advantages, however, the farmer did not prosper, as we reckon prosperity in these modern times of wealth. The colonist could produce an abundance to eat, his wife or his neighbor could supply him with coarse homespun clothes, and the entire community could join in a happy log rolling to clear his land or build him a house, but beyond this he could not go. With the rude home made implements that belonged to the age of the sickle, a man could not produce a surplus, and hence could not acquire wealth or a cash income that would enable him to buy the products of modern factories. In the South, where slave labor was available, the planters lived in luxury, but the Northern farmer, excepting for his abundance of food, was a man of poverty, who toiled from sun to sun and enjoyed but few of what we now look upon as the comforts of life. During the age of the sickle, farming was an occupation. Harvesting machines and other labor saving inventions have made agriculture a business in which a man can produce a surplus far beyond his own wants—a surplus which he can exchange in the world's markets for cash or for the products of a thousand factories.

The harvesting machine industry began with the invention of the reaper in 1831 by Cyrus H. McCormick of Rockbridge County, Va. Robert McCormick, his father, a wealthy planter, had made a number of experiments, beginning as early as 1816, in an effort to construct a practical reaping machine, but these experiments had ended in failure. Cyrus, his son, then coming to manhood, took up the work in 1831 and carried it on to success.

Many English writers have endeavored to claim for their countrymen the credit that we give to McCormick for this epoch making invention. If the honor belongs to the man who first tried to invent a reaper, English inventors could undoubtedly establish priority over McCormick, but this is not the standard by which we measure inventions. It is curious to note that nearly all the English inventors who applied for patents prior to 1831, proposed to cut the grain with circular knives or saws, the same principle that Robert McCormick tried in his first experimental machine in 1816. Credit is also claimed for two other English inventors, neither of whom ever applied for a patent. Their inventions, like all the other conceptions of inventors of their period, need not be considered by any one familiar with the essential principles of a harvesting machine, as they were not practical, and nothing more was heard of them until McCormick appeared at the London Exposition in 1851 with a reaper that would reap.

When we look back over the wilderness of patents on harvesting machines that has become visible to us in the past 70 years, it is remarkable that a young planter's son, like Cyrus H. McCormick, with nothing to guide him except the failures of his father, should have been able to embody in his first machine the foundation principles of all modern reapers and harvesters. These were the balancing of the frame on two wheels, one of which was geared to furnish power to the moving parts; the reciprocating knife moving through or over fixed fingers, actuated by a crank; the platform to receive the grain as cut and hold it until a gavel had been gathered, and, most important of all, the arrangement of a stationary divider and a revolving reel in such a manner as to separate the grain to be cut from the standing grain, and lay it in a flowing swath upon the platform.

McCormick's invention seems very simple to us now, when we look back and review the additions and improvements that have been made to bring harvesting machines to their present standard, but we must remember that McCormick occupied the position of a pioneer. We might say that 100 years ago the world was blind in its mechanical eye. A few men, like Watt, Stephenson, Fulton, Whitney, and Arkwright, had acquired the power of sight in their respective fields of invention. A score of men had seen a glimmering of light in the direction of harvesting grain mechanically, but the honor was reserved for McCormick to look upon the problem with the clear eye of the constructive genius, and his business acumen and determination led him to toil on at his invention until his vision had become a reality and he was able to manufacture and sell machines in large numbers.

During the early history of harvesting machines it required about as much genius, and of an entirely different order, to establish the manufacture of an invention, as to conceive and work out experimentally the invention itself. There were no factories then with staffs of experienced master mechanics to put all the details of an invention in shape and to give each part the requisite strength, at the same time preserving the necessary economy in weight for a machine that must be drawn by horses. The difficulty in obtaining the necessary variety of materials was a staggering one in itself. So insurmountable did these obstacles appear that Mr. McCormick, after patenting the reaper in 1834, was persuaded to abandon his invention and go into partnership with a neighbor in establishing a blast furnace. Probably the difficulty of obtaining iron for making reapers led him to believe that it would be a wise step to be able to make his own iron and thus obtain an important advantage in putting his invention on the market. The blast furnace, however, did not prove

profitable and was closed out five years later. Mr. McCormick then, in 1839, returned to the problem of the reaper, and thereafter gave his long and active life to the development and manufacture of harvesting machines.

In the year book of the Department of Agriculture for 1899 appears a statement regarding Mr. McCormick's first steps in manufacturing which throws a strong light upon the obstacles that the pioneer manufacturers had to surmount, as follows:

"When agricultural machinery began to be manufactured at Walnut Grove, Va., great difficulty was experienced in procuring some of the material, which had to be brought from a distance. Neither was it easy, when the machines were manufactured, to get them to market. Sickles were made 40 miles away, but as there were no railroads and but few highways fit for wagons, the blades, 6 feet long, had to be carried on horseback. It was soon realized that while reapers were luxuries in Virginia and the East, they were a necessity in Ohio and Illinois and on the plains of the great West. When it was discovered that the West was the natural market for these agricultural machines, the next and most difficult question was that of getting them there. The question was finally solved by shipping the first consignment, in 1844, by wagon trains from Walnut Grove, to Scottsville, Va., thence down the canal to Richmond, thence by water down the James River into the Atlantic and around Florida into the Gulf of Mexico, thence by way of New Orleans up the Mississippi and Ohio rivers to Cincinnati, Ohio."

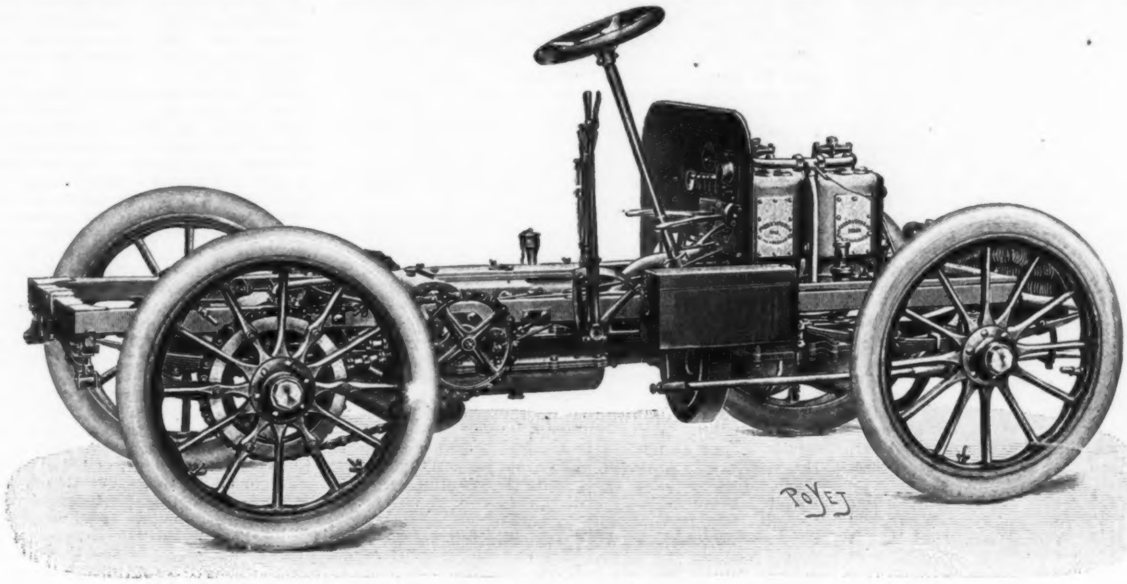


FIG. 3.—C. G. V. 16 HORSE POWER FRAME—RIGHT-HAND SIDE.

Finding it impracticable to establish the manufacture of reapers on a successful scale in Virginia Mr. McCormick had 100 machines made at Cincinnati in 1845, under the supervision of his younger brother, Leander J. McCormick. The next year, 1846, Cyrus H. McCormick went to Brockport, N. Y., where he built 100 reapers in the Globe Iron Works, owned by Seymour & Morgan. In 1847 Mr. McCormick removed to Chicago and made 500 machines the first season, locating there permanently and building up the great industry which has made the name McCormick a household word throughout the world. Seymour & Morgan, however, continued to manufacture reapers at Brockport. In later years the firm became D. S. Morgan & Co., but the business was wound up a few years ago. Mr. Seymour still lives in Brockport, having recently celebrated his one hundredth birthday. He has the honor of being the oldest living reaper manufacturer in the world and the only man now living who was engaged in the industry prior to 1850.

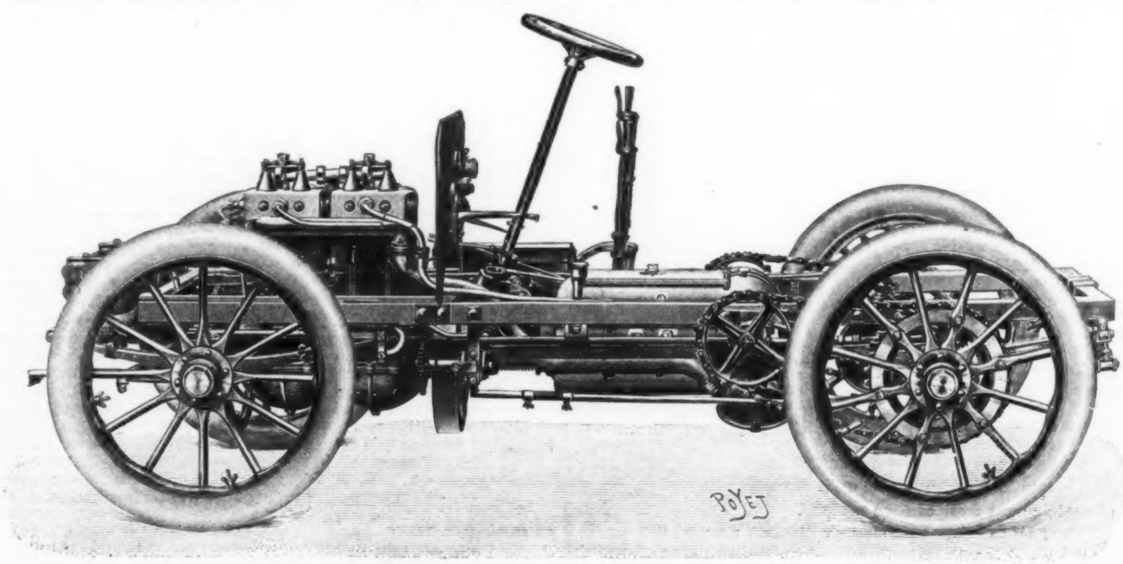


FIG. 4.—C. G. V. 16 HORSE POWER FRAME—LEFT-HAND SIDE.

Obed Hussey was a noted inventor who enjoys the distinction of being the only American rival to McCormick for the honor of inventing the reaper. Hussey invented and built his reaper in 1833, operating it successfully in the harvest of that year. His patent antedates that of McCormick, bearing date of December 31, 1833, while McCormick's patent was not issued until June 21, 1834. Inventions, however, are reckoned by the date when they are conceived and put into successful operation, and this gives McCormick two years' priority over Hussey. The notable feature of Hussey's machine was the use of a "scalloped" knife, made in triangular sections which were attached to a back or bar, this knife running through slotted guards or fingers. McCormick in his first machine used a straight knife, which was later given a serrated or sickle edge, and his guards were given a spear head shape, so that this sickle would cut against the rear shoulder, holding the grain at an acute angle. In 1847 Hussey patented an improvement on his guard, in which the upper part was cut away at the rear, so that the grain, as it passed over, would sweep out the trash that had tended to accumulate in the slot. Guards and sections of the Hussey type are now in universal use in all harvesting machines. McCormick's device, however, worked successfully, and was used by him for a number of years in thousands of machines that he manufactured.

The real distinction between the inventions of McCormick and Hussey is that one was essentially a reaping machine, while the other was essentially a mowing machine. There are four vital elements in a reaper—vital in the sense that if any one of them be omitted the machine will not be practical for general use. These are the reciprocating knife, the platform, the reel, and the divider. McCormick was the first inventor to embody these four vital elements in practical form in one machine. Hussey had only two of them in practical form, the reciprocating knife and the platform, and while his machines were sold and used to a limited extent as reapers, they were not practical for general use as reapers; just as McCormick reapers were used to a limited extent as mowers, but were not practical as compared with advantages which the Hussey type of machine possessed as a mower. There are two problems in reaping or harvesting grain; first, the cutting and, second, the handling of the grain in such a manner as to keep it straight and in shape for binding. McCormick's success where other inventors, including his father, had failed, was due to the fact that he mastered the problem of dividing the swath from the standing grain, reeling it in, and laying it by a positive and simple action upon the platform. Hussey seems never to have comprehended the importance of this half of the problem of reaping, but confined his attention almost entirely to his devices for cutting. Grain is easy to cut but difficult to handle. Grass is hard to cut but requires no handling. Grain can only be harvested successfully by using the devices for handling it that are peculiar to the McCormick invention; grass can only be cut successfully by using the cutting mechanism of Hussey.

Those who have sought to give to Hussey the credit for the invention of the reaper, overlooking the great honor to which he is unquestionably entitled as the inventor of the foundation features of mowing machines, seem to have echoed the great mistake which Hussey himself made during his life. Instead of developing his machine and securing its general introduction as a mower, he persisted all his life in unprofitable efforts to introduce it as a reaper. He, in fact, never made any money out of his inventions until, two years before the expiration of his patent of 1847, a syndicate of patent lawyers bought the patent, paying him $200,000. A few years before, Hussey had made application to the Court of Claims for a reward from Congress for his invention, making the statement that after years of hard and continuous work in the introduction of his machines he was not worth to exceed $500 above his liabilities.

In the general construction of the two machines, aside from their working devices, the distinction between them, the one as a reaper and the other as a mower, is equally clear. McCormick balanced his reaper on two wheels, one, the master wheel, at the stubble end of the rigid frame, and the other, the grain wheel, at the grainward end, so that his reaper could be maneuvered in the field like a cart, and this plan is followed in all modern grain harvesting machines. Hussey, on the other hand, had a two wheeled truck, in form substantially like the truck of modern mowers, in place of the one master wheel of McCormick; and in addition to the grain wheel it was necessary to have a castor wheel at the rear to support the platform. This made the Hussey machine, as a reaper, difficult to maneuver in the field, as well as more expensive to manufacture.

Leaving off the two superfluous wheels and the platform, the Hussey machine embodied the foundation principles of a mower. His bar could be connected to the main truck by a hinge, so that the outer end could rise and fall and conform to the inequalities of the ground, an essential feature of a mower, which must cut close to the ground in order to get all the grass. It was unfortunate that Mr. Hussey was unable to reap a financial reward more commensurate with his merits as a pioneer inventor. He did not live to enjoy the fortune which he finally received for his patent on the "open back" guard, as he lost his life in a railway accident a year or two later.

The ten years following 1850 were years of great progress in the manufacture of reapers and mowers. A few pioneers had tapped the great, inexhaustible fountains of American inventive genius, and a stream of labor-saving agricultural inventions poured forth to

lighten the burdens of those who produce the world's bread. New factories were established in all parts of the country, each based on some improvement upon or variation from the prevailing types of harvesting machines. The oldest enterprise, next to the McCormick Company, was established at Springfield, Ohio, in 1850, by Benjamin H. Warder, which grew into the Warder, Bushnell & Glessner Company, who have made the Champion harvesting machines famous throughout the world. William H. Whitely, a farmer's boy, also came to Springfield early in the '50s and began making reapers, his enterprise growing into the Whitely, Fassler & Kelly Company, who at one time, about 1880, operated the largest agricultural machine works in the world, the firm going out of business in 1886. The late Walter A. Wood established at Hoosick Falls, N. Y., the business which grew into the Walter A. Wood Mowing & Reaping Machine Company, and D. M. Osborne laid the foundations at Auburn, N. Y., for the great business of D. M. Osborne & Co. In the West, Emerson, Talcott & Co. of Rockford, Ill., made the Manny reaper famous, but in recent years they have confined their attention to mowing machines. Ball, Aultman & Co. of Canton, Ohio, who were eventually succeeded by Aultman, Miller & Co. of Akron, Ohio, also began during this period, they having been the pioneers in the manufacture of "hinged bar" mowers. This practically covers the list of reaper manufacturers who began prior to 1860 and are still doing business successfully.

William F. Ketchum of Buffalo, N. Y., was the first to manufacture mowers which were designed exclusively for cutting grass, his machine being made with one drive wheel and a rigid bar. Lewis F. Miller, who was then connected with the firm of Ball, Aultman & Co. (licensees of Hussey), but later became the head of the firm of Aultman, Miller & Co. at Akron, is recognized as the inventor of the "hinged bar" type of mower, which, with improvements, is now in universal use. Following the general plan of construction of the Hussey machine, which his firm were building, Mr. Miller designed his mower with two drivers, and the bar was hinged and so attached to the frame of the truck that it could be raised entirely by means of a lever to pass obstructions or for convenience in turning at corners, and the inner and outer ends could rise and fall independently when cutting, so as to float over the ground and conform to the inequalities of the field. The main features of this machine were patented in 1858. By this time, however, so many patents had been issued on reapers and mowers that it was found that many of the features of the Miller hinged bar had been anticipated by prior inventors, and while this did not detract from the historical credit that is due to Mr. Miller as the man who perfected the "hinged bar" mower, it created many difficulties for his firm, as manufacturers, especially when they attempted to collect royalties from other firms or damages for infringement of their patents. As a result of this conflict of interests the famous "hinged bar pool" of patents was organized, under the leadership of Cornelius Aultman, who was one of the shrewdest of the reaper and mower manufacturers of his day. The conflicting patents were bought or merged in this "pool," which eventually collected more than a million dollars in royalties and settlements from other manufacturers. This was probably the largest sum that was ever realized from patents by any one interest in the harvesting machine industry.

The "combined" machine, combining a reaper and mower in one, seems to have been the foremost idea in the minds of a majority of the manufacturers of this period. The correct plan of construction in a reaper or harvester is to make the frame and cutter bar rigid, so that the machine must be raised and lowered on its supporting wheels to change the height at which the bar cuts. In a mower, however, the bar must be attached flexibly to the frame, so it will float closely over the ground, and great difficulty was found in reconciling these two requirements in one machine. When mowers were improved by the construction of a double hinge in the bar it was found that the bar could be raised permanently to any height desired for cutting grain. The platform, grain wheel divider and reeling or raking attachments could then be put on, these devices being so constructed that the farmer could readily attach them for reaping or take them off again to convert the machine into a mower. In some cases the McCormick type of reel was used, the same as in modern harvesters, but the reel rake, which is now used on reapers, became the most popular on combined machines. In the reel rake each rake is attached at one end to a central, revolving rake head, the outer end of the rake or arm being left free to describe an eccentric circle, under control of a roller bearing which runs on a track on the rake head. The inventor who put this device in practical form was Samuel Johnston, founder of the Johnston Harvester Company of Batavia, N. Y., but the leading manufacturers were the Champion interests of Springfield, Ohio. The efforts of William N. Whitely were directed for nearly 30 years to the improvement of combined machines. He was an exceedingly practical inventor, and his East Street shops in Springfield, as before stated, became noted as the largest agricultural machine works of their day in the world, and Springfield had besides two other large manufacturers operating under a division of territory on Champion patents. One of these three concerns, the Warder, Bushnell & Glessner Company, has since recovered much of the ground that was lost by the unfortunate failure of the Whitely interests in 1886.

While these great improvements in reapers and mowers were in progress a new type of harvesting machine came to the front in the West, and continues in use to the present day wherever the climatic conditions are favorable. This was the "header," a machine which merely "topped" the wheat, leaving the straw on the ground. The pioneer inventor in this field was George Esterly of Wisconsin, who, until his death a few years ago, was one of the leading manufacturers of headers. Esterly's first patent in 1844 showed merely a box mounted on wheels and pushed by horses from the rear —a wide "push cart"—with a stationary knife in front and a rotating reel with beaters which carried the grain against the knife and swept the heads back into the box. In later patents a platform canvas is shown, which carried the heads to one side, and a canvas elevator which delivered them into a wagon driven alongside. Jonathan Haines of Illinois was also a pioneer in this field, and made many improvements which made Haines' Illinois harvester a very popular machine in its day. Several thousand "headers" are now sold annually in the far West. They are fitted with the same cutting apparatus as a harvester, and generally cut 12 or 14 feet, twice the width of harvesters in common use—a machine being pushed by four to six horses.

In California and in portions of Oregon and Washington "combined" harvesters are used which harvest and thresh the grain at one operation. These machines, which are drawn by horses or by traction engines, combine the "header" with a threshing attachment, cutting a swath of 12 to 40 feet, and delivering the threshed wheat in bags which are dropped in the field. While these machines have only come into use in the past 20 years the main principles embodied in them are shown in a patent granted in 1836 to Moore and Hascall of Michigan, who endeavored to introduce them at that early period, but found the climate an insuperable obstacle.

These are probably the most economical harvesting machines in use to-day, but they can only be employed where the harvest season is dry.

The year 1858 marked a turning point in the art of harvesting grain. In that year C. W. and W. W. Marsh of Shabbona Grove, Ill., invented and built a machine for which they adopted the name "harvester," to distinguish it as a type from the reapers then in general use. It was so constructed that two men could stand on it and bind the grain as fast as it was cut, dropping the bound bundles behind them on the ground or on a bundle carrier. Several manufacturers were then putting out "self raking" reapers, which raked the grain off in gavels mechanically, thus requiring only a man to drive the machine, but most of the reapers in use at this time were of the old hand raking type, and required a man to drive and another to stand or sit on the machine and rake off the gavels from the platform with a fork or hand rake. The Marsh Brothers constructed their machine with an endless conveyor on the platform, and an elevator with a "band of rakes," so that the grain, as it was cut and fell on the platform, was carried to one side and elevated over the master wheel into a receptacle. Two men stood on a platform or foot board arranged on the outside of the machine and bound the grain as fast as it was delivered to them, each taking a gavel from the receptacle and binding it on a table at his side. With this "harvester" two men and a boy could harvest and bind 8 to 12 acres per day, and this meant an enormous saving in labor as compared with the reaper, which usually required five men to follow it and bind on the ground. In 1860 the Marsh Brothers undertook to build 12 of their harvesters for sale to their neighbors, but they encountered obstacles which have usually proved fatal to inventors of agricultural machines. With no plant of their own and no experience in manufacturing their machines proved to be poorly built, and would not stand up in the field. Baffled and financially embarrassed, but not vanquished, they built another experimental machine at Plano in 1861. This machine worked well, and they decided to run it for several years before undertaking again to manufacture harvesters. They had learned by sad experience that a machine which works well in the hands of its inventors, who know how to handle it and keep it together, is a different proposition from the construction of machines that are to be put out in the hands of farmers, who are seldom skilled mechanics, and who will drive a "new fangled" invention into the fence corner and have nothing more to do with it if it gives them any trouble. In 1864, however, the Marsh Brothers considered their harvester sufficiently developed for the test of sale, and 26 machines were built for the harvest of that year, which stood up well and gave satisfaction to the farmers who bought them. They had formed a partnership with Lewis and George Stewart of Plano for the manufacture of these machines, and this eventually grew into the great manufacturing business of the Deering Harvester Company at Chicago, who in recent years have stood on an equality with the McCormick Harvesting Machine Company, each making nearly a third of the harvesting machines of the world.

"Field trials" were the great battle ground of the harvesting machine industry a generation ago. "For ways that are dark and tricks that are vain," the heathen Chinee and modern horse trainers and jockeys are mere innocent babes as compared with the experts who used to represent the reaper companies and operate their machines in these great contests. The farmers in a radius of 25 to 50 miles would gather at these events, inspired by a practical desire to keep pace with the progress of the manufacturers, as well as the love of a tremendous competition in which the contestants did not resort to violence. It was always a serious matter for the manufacturer, especially since "the boys" had a way of conspiring to beat McCormick, or whoever had the lead in the trade of the community where the trial was held. Victory depended as much upon the personal and entertaining ability of the manufacturer's staff of men as upon the work of his machine, but the latter was always managed by experts who could astonish the natives by the wonders that they performed.

At one of these famous "field trials," held at Dekalb, Ill., in 1864, one of the Marsh harvesters that had been built at Plano that year made its appearance. W. W. Marsh, one of the inventors, rode alone on this machine and cut and bound an acre of wheat in 55 minutes. Shortly after this trial Easter & Gammon of Chicago obtained a license from the Marsh Brothers to manufacture and sell their harvesters in six of the principal States. They were experienced reaper men, and under their leadership the Marsh harvester soon became recognized as a successful and practical machine. Two years later Easter & Gammon dissolved partnership and divided their territory, Mr. Gammon having his machines built at Plano by Marsh Bros. & Steward, while Mr. Easter had his machines built at Rockford, Ill., by Emerson, Talcott & Co.

In 1870, William Deering, then of Portland, Maine, who had been a financial backer in part for some years, became a member with Mr. Gammon of the firm of Gammon, Deering & Steward, later Gammon & Deering.

Mr. Deering, before becoming interested in the harvester, had been very successful as a manufacturer, and had accumulated what was regarded 30 years ago as a comfortable fortune. The harvester needed capital, and it also needed the commercial genius which Mr. Deering was able to supply. He at once became the leader among the group of men who were interested in the machine, and under his shrewd, conservative direction the business grew by leaps and bounds. Rights for other States were added to their territory from time to time by arrangement with the Marsh Brothers, and after 1877 Gammon & Deering took over the business of J. D. Easter and the manufacturing interests of the Marsh Brothers in the harvester, the Marshes having some years before established a factory at Sycamore, where they had manufactured machines for J. D. Easter & Co. for territory controlled by themselves and by that firm.

While the manufacture of Marsh harvesters grew to large proportions, about 100,000 machines having been sold during the life of the Marsh patents, this business proved but the introduction to the enormous industry that has since grown up in the manufacture of the harvester and binder. The problem of binding grain mechanically had long engaged the attention of inventors, the first patent on an automatic binder having been granted as early as 1850. Some of the devices shown in these early patents were later incorporated in wire and twine binders, but it was not until after the introduction of the Marsh harvester that successful binders made their appearance, and then only as attachments to this machine. The leading wire binders were the Locke, made by Walter A. Wood; the Gordon, made by Gammon & Deering, and the Withington, made by McCormick.

It is a curious fact that it would cost more to harvest grain with a wire binder, or even with machines using twine, than with a Marsh harvester, yet the demand for automatic binders was such that for many years after their introduction the manufacturers could not supply the demand. As one of the pioneers of that period has explained, what the farmers wanted was facility in the work of harvesting. Labor was becoming scarce on the farms, and the farmer wanted a machine that would make him independent, so that he could cut and bind his crop himself. Prior to the Civil War there had been an abundance of labor available for agriculture, but at the close of the war the men who were discharged from the service preferred to go West and make homes for themselves under the military homestead law. Even as late as 1880 there was an abundance of land awaiting settlement, and the prospect of acquiring a farm was more inviting to the young man of the Central States than the life of an agricultural laborer or renter. This demand for automatic machines was a great stimulus to the efforts of inventors, and the trouble that was encountered in the use of wire which remained in the straw, as well as in the threshed grain, directed attention to the possibilities of using cord or twine.

Many inventors contributed to the combination of ideas that make up a practical twine binder, but Marquis L. Gorham and John F. Appleby carried the work on to success. Gorham's patent was issued in 1875, and had he lived it is probable that he would have done much to solve the problem of a practical twine binder, as he was an experienced inventor in the designing of agricultural implements and machines. Death cut short his career, however, and it was left to Appleby to perfect the machine that swept the harvest fields of the world under the name of the Appleby binder. Mr. Appleby's first patent on an automatic binder (using wire) was issued in 1869, but it was not until eight or nine years later that he was able to build a machine that would work successfully with twine. William Deering had been watching his experiments closely, hoping that they would offer a solution of the great problem of binding grain in a more satisfactory manner than with wire. Two of the machines built by Mr. Appleby for him were operated by Mr. Deering through the harvest of 1878, under an agreement which in the fall of that year, 1878, was put in writing, giving Mr. Deering rights under the Appleby patents. About 100 Appleby binders were built by Gammon & Deering in 1879, preparatory to putting the machines on the market in large numbers the following year.

The firm of Gammon & Deering dissolved partnership in 1879, Mr. Gammon retiring with a fortune of about $1,000,000. Mr. Deering, finding that the shops at Plano, Ill., where their manufacturing operations had been carried on, were inadequate and could not be enlarged materially because of their location in the center of the town, besides the lack of railroad facilities, decided to remove to Chicago, and accordingly bought a large tract of ground at Clybourn and Fullerton avenues, on the north branch of the Chicago River, where the great plant of the Deering Harvester Company is now located. The following paragraph, descriptive of the difficulties which he had to overcome and his final triumph, is from the pen of C. W. Marsh, editor of the Farm Implement News of Chicago, who was one of the inventors of the harvester and had been for many years associated with Mr. Deering:

"The year 1880 was a memorable one in the annals of the harvesting machine business. The old hand binding harvester had been pushed from its place in the market by the child of its adoption, the automatic binder, several styles of which binding with wire were built and successfully put upon the market to supply a large and growing demand. Mr. Deering was now the sole representative of the vast interests of the old concern, and he was making two bold movements; he was building new shops in Chicago, and removing his works thereto from Plano, thus changing his base and reforming his front in the face of the enemy, and he was preparing to make a charge directly upon the center of the opposing hosts. The position was dangerous and required a leader of judgment, nerve, great executive ability and force of character. These attributes Mr. Deering possessed. The campaign of 1880 ended in complete success; his Appleby binders—manufactured and put upon the market from shops on wheels, so to speak—swept everything before them. The harvest of that year was a Waterloo defeat for the wire binders, and "*Sauve qui peut*" might well have been the cry of the leaders thereafter as they rushed for cover under the Appleby patents. Mr. Deering won a complete victory; he established twine binding machines as the grain harvesters of the time,

and of the future, and himself as the acknowledged leader in the movement."

With this auspicious introduction of the twine binder the Deering establishment soon became one of the two greatest works in the world for the manufacture of labor saving farm machines. The harvester of 1858, rudely constructed by two farmer's boys, with the aid of castings from an old reaper, was an acorn from which a giant industrial oak has grown. Step by step the labor of the harvest field has been lightened by Deering improvements and inventions, until the world has demanded each year more than a quarter of a million Deering harvesting machines. The organizing genius and executive ability of William Deering have been ably seconded by his sons, Charles and James Deering, and, in recent years, his son-in-law, Richard F. Howe. After 30 years of titanic labor William Deering withdrew the first of the present year from the Deering Harvester Company, transferring his interest to his sons and to Mr. Howe, carrying with him the respect and admiration of the world for the "grand old man" of the harvesting machine industry.

This great industry, however, is much like the Western Continent, in the sense that one man could discover it, but one man cannot conquer or rule it. Mr. McCormick, who gave to the world the reaping machine, found, when he went forth into the field with his great invention, a host of antagonists who did not hesitate to challenge him to mortal commercial combat, and who showed themselves ever ready to make improvements upon his own weapon. Mr. Deering, in like manner, in his hour of triumph in the introduction of the Appleby binder, found himself pitted against the great McCormick Company, who bought the Gorham patents, as well as some 20 other manufacturers, who took licenses under the Appleby patents. The McCormick Company, in particular, have been noted for their ability to keep pace with or in the van of all great improvements in this industry. When they began building harvesters of the Marsh type in 1875 they made many improvements in the machine, the most important of which was the use of canvas aprons instead of the "band of rakes" which had been used by the Marsh interests. Their wire binder was the most successful machine of its type. It is estimated that a few years before the invention of the Appleby binder there were nearly a hundred manufacturers of reapers and mowers in the United States. Only 22 concerns equipped themselves for the manufacture of twine binders, the remainder, with a few exceptions, soon dropping out of the field. A few years after the introduction of the twine binder the great change in construction was made from wood to steel, and the cost of the shop equipment for making steel machines was so great that there was a further reduction in the ranks, until to-day there are only 12 manufacturers of binders in the United States. Of these the McCormick and Deering companies are by far the largest, each of these two great establishments having made nearly a third of the world's harvesting machines in recent years. Next to them come in the order named the Warder, Bushnell & Glessner Company of Springfield, Ohio; the Plano Manufacturing Company, located at Plano, Ill., the home of the harvester, until 1893, when they removed to Chicago, and the Milwaukee Harvester Company of Milwaukee, Wis. These five are the companies that have recently been merged in the International Harvester Company. The Warder, Bushnell & Glessner Company was founded at Springfield by the late Benjamin H. Warder. Gen. Asa S. Bushnell, who recently filled with credit to himself, as well as to the State, the office of Governor of Ohio, is president; he and J. J. Glessner of Chicago, the vice-president, being the principal owners. The Plano Manufacturing Company was established at Plano, Ill., in 1881, by W. H. Jones, E. H. Gammon and Lewis Steward, and operated the plant which had been vacated by Mr. Deering's removal to Chicago until they, too, outgrew the facilities of the shops and removed to West Pullman, in Chicago.

There are seven manufacturers of binders who are not included in this great consolidation, as follows:

Acme Harvester Company, Pekin, Ill.
Adriance, Platt & Co., Poughkeepsie, N. Y.
Aultman, Miller & Co., Akron, Ohio.
Johnston Harvester Company, Batavia, N. Y.
Northwestern Grass Twine Company, St. Paul, Minn.
D. M. Osborne & Co., Auburn, N. Y.
Walter A. Wood Mowing & Reaping Machine Company, Hoosick Falls, N. Y.

The Emerson Manufacturing Company of Rockford, Ill., and the Richardson Manufacturing Company of Worcester, Mass., and a number of smaller concerns are engaged in the manufacture of mowers on a considerable scale. There has been, however, an enormous development of the mower business of the five "international" companies in the past ten years. The introduction of roller and ball bearings in the Deering mower has been well matched by improvements in the McCormick machine which give it unsurpassed efficiency and durability, and the two companies probably do nearly ten times the business in mowers that they had 10 or 15 years ago.

The introduction of successful corn harvesting machines has been the great event of the past decade in this industry. Both the McCormick and Deering companies experimented for many years with inventions for cutting and binding the corn crop, and both had machines on exhibition at the Columbian Exposition which did fair work in the field trials. Recently, however, this business has attained large proportions, and the two pioneer companies will probably do a business the present season in corn harvesters aggregating several millions of dollars. The acreage of corn in the United States is nearly double the acreage of wheat, and it would not be surprising if the output of corn harvesters in the course of 10 or 20 years, would exceed the number of grain binders sold in the United States.

It would be rash to make any prophecies of the future of the harvesting machine industry. The past 50 years have shown a continual expansion, some new development arising at every stage to carry it on to new triumphs. When Cyrus H. McCormick, the founder of the McCormick Harvesting Machine Company, was summoned to the harvest of the Infinite Reaper in 1884 he could look back over a long and eminently successful career, and the great establishment which he had built up seemed like a colossal monument of industry which his successors would be fortunate to maintain. Yet under the administration of his son, Cyrus H. McCormick (who becomes president of the International Harvester Company), assisted in recent years by a younger son, Horace F. McCormick, as vice-president and general manager of the company, the output of the McCormick Works has increased about five fold; and the business has been so extended throughout the world that, in all of our seasons of the year, from January to December, the last rays of the setting sun cast their benediction upon some modern harvest scene where slaves of steel, bearing the name of that great master, McCormick, are employed in the beneficent work of harvesting the world's bread.—Iron Age.

TYNDALL AND EVOLUTION.*

THE Presidential Address delivered by Tyndall in this city twenty-eight years ago will always rank as an epoch-making deliverance. Of all the men of the time, Tyndall was one of the best equipped for the presentation of a vast and complicated scientific subject to the mass of his fellow-men. Gifted with the powers of a many-sided original investigator, he had at the same time devoted much of his time to an earnest study of philosophy, and his literary and oratorical powers, coupled with a fine poetic instinct, were qualifications which placed him in the front rank of the scientific representatives of the later Victorian epoch and constituted him an exceptionally endowed exponent of scientific thought. In the Belfast discourse Tyndall dealt with the changing aspects of the long unsettled horizon of human thought, at last illuminated by the sunrise of the doctrine of evolution. The consummate art with which he marshaled his scientific forces for the purpose of effecting conviction of the general truth of the doctrine has rarely been surpassed. The courage, the lucidity, the grasp of principles, the moral enthusiasm with which he treated his great theme, have powerfully aided in effecting a great intellectual conquest, and the victory assuredly ought to engender no regrets.

Tyndall's views as a strenuous supporter and believer in the theory of evolution were naturally essentially optimistic. He had no sympathy with the lugubrious pessimistic philosophy whose disciples are for ever intent on administering rebuke to scientific workers by reminding them that, however much knowledge man may have acquired, it is as nothing compared with the immensity of his ignorance. That truth is indeed never adequately realized except by the man of science, to whom it is brought home by repeated experience of the fact that his most promising excursions into the unknown are invariably terminated by barriers which, for the time at least, are insurmountable. He who has never made such excursions with patient labor may indeed prattle about the vastness of the unknown, but he does so without real sincerity or intimate conviction. His tacit, if not his avowed, contention is, that since we can never know all, it is not worth while to seek to know more, and that in the profoundity of his ignorance he has the right to people the unexplored spaces with the phantoms of his vain imagining. The man of science, on the contrary, finds in the extent of his ignorance a perpetual incentive to further exertion, and in the mysteries that surround him a continual invitation, nay, more, an inexorable mandate. Tyndall's writings abundantly prove that he had faced the great problems of man's existence with that calm intellectual courage, the lack of which goes very far to explain the nervous dogmatism of nescience. Just because he had done this, because he had, as it were, mapped out the boundaries between what is knowable though not yet known and what must remain forever unknowable to man, he did not hesitate to place implicit reliance on the progress of which man is capable, through the exercise of patient and persistent research. In Tyndall's scheme of thought the chief dicta were the strict division of the world of knowledge from that of emotion, and the lifting of life by throwing overboard the malign residuum of dogmatism, fanaticism, and intolerance, thereby stimulating and nourishing a plastic vigor of intellect. His cry was "Commotion before stagnation, the leap of the torrent before the stillness of the swamp."

His successors have no longer any need to repeat those significant words, "We claim and we shall wrest from theology the entire domain of cosmological theory." The claim has been practically, though often unconsciously, conceded. Tyndall's dictum, "Every system must be plastic to the extent that the growth of knowledge demands," struck a note that was too often absent from the heated discussions of days that now seem so strangely remote. His honorable admissions that, after all that had been achieved by the developmental theory, "the whole process of evolution is the manifestation of a power absolutely inscrutable to the intellect of man," shows how willingly he acknowledged the necessary limits of scientific inquiry. This reservation did not prevent him from expressing the conviction forced upon him by the pressure of intellectual necessity, after exhaustive consideration of the known relations of living things, that matter in itself must be regarded as containing the promise and potency of all terrestrial life. Bacon in his day said very much the same thing: "He that will know the properties and proceedings of matter should comprehend in his understanding the sum of all things, which have been, which are, and which shall be, although no knowledge can extend so far as to singular and individual beings." Tyndall's conclusion was at the time thought to be based on a too insecure projection into the unknown, and some even regarded such an expansion of the crude properties of matter as totally unwarranted. Yet Tyndall was certainly no materialist in the ordinary acceptation of the term. It is true his arguments, like all arguments, were capable of being distorted, especially when taken out of their context, and the address became in this way an easy prey for hostile criticism. The glowing rhetoric that gave charm to his discourse and the poetic similes that clothed the dry bones of his close-woven logic were attacked by a veritable broadside of critical artillery. At the present day these would be considered as only appropriate artistic embellishments, so great is the unconscious change wrought in our surroundings. It must be remembered that, while Tyndall discussed the evolutionary problem from many points of view, he took up the position of a practical disciple of Nature dealing with the known experimental and observational realities of physical inquiry. Thus he accepted as fundamental concepts the atomic theory, together with the capacity of the atom to be the vehicle or repository of energy, and the grand generalization of the conservation of energy. Without the former, Tyndall doubted whether it would be possible to frame a theory of the material universe; and as to the latter he recognized its radical significance in that the ultimate philosophical issues therein involved were as yet but dimly seen. That such generalizations are provisionally accepted does not mean that science is not alive to the possibility that what may now be regarded as fundamental may in future be superseded or absorbed by a wider generalization. It is only the poverty of language and the necessity for compendious expression that oblige the man of science to resort to metaphor and to speak of the laws of Nature. In reality, he does not pretend to formulate any laws for Nature, since to do so would be to assume a knowledge of the inscrutable cause from which alone such laws could emanate. When he speaks of a "law of Nature," he simply indicates a sequence of events which, so far as his experience goes, is invariable, and which therefore enables him to predict, to a certain extent, what will happen in given circumstances. But, however seemingly bold may be the speculation in which he permits himself to indulge, he does not claim for his best hypothesis more than provisional validity. He does not forget that to-morrow may bring a new experience compelling him to re-cast the hypothesis of to-day. This plasticity of scientific thought, depending upon reverent recognition of the vastness of the unknown, is oddly made a matter of reproach by the very people who harp upon the limitations of human knowledge. Yet the essential condition of progress is that we should generalize to the best of our ability from the experience at command, treat our theory as provisionally true, endeavor to the best of our power to reconcile with it all the new facts we discover, and abandon or modify it when it ceases to afford a coherent explanation of new experience. That procedure is far as are the poles asunder from the presumptuous attempt to travel beyond the study of secondary causes. Any discussion as to whether matter or energy was the true reality would have appeared to Tyndall as a futile metaphysical disputation, which being completely dissociated from verified experience, would lead to nothing. No explanation was attempted by him of the origin of the bodies we call elements, nor how some of such bodies came to be compounded into complex groupings and built up into special structures with which, so far as we know, the phenomena characteristic of life are invariably associated. The evolutionary doctrine leads us to the conclusion that life, such as we know it, has only been possible during a short period of the world's history, and seems equally destined to disappear in the remote future; but it postulates the existence of a material universe endowed with an infinity of powers and properties, the origin of which it does not pretend to account for. The enigma at both ends of the scale Tyndall admitted, and the futility of attempting to answer such questions he fully recognized. Nevertheless, Tyndall did not mean that the man of science should be debarred from speculating as to the possible nature of the simplest forms of matter or the mode in which life may have originated on this planet. Lord Kelvin, in his Presidential Address, put the position admirably when he said, "Science is bound by the everlasting law of honor to face fearlessly every problem that can fairly be presented to it. If a probable solution consistent with the ordinary course of Nature can be found, we must not invoke an abnormal act of Creative Power"; and in illustration he forthwith proceeded to express his conviction that from time immemorial many worlds of life besides our own have existed, and that "it is not an unscientific hypothesis that life originated on this earth through the moss-grown fragments from the ruins of another world." In spite of the great progress made in science, it is curious to notice the occasional recrudescence of metaphysical dogma. For instance, there is a school which does not hesitate to revive ancient mystifications in order to show that matter and energy can be shattered by philosophical arguments, and have no objective reality. Science is at once more humble and more reverent. She confesses her ignorance of the ultimate nature of matter, of the ultimate nature of energy, and still more of the origin and ultimate synthesis of the two. She is content with her patient investigation of secondary causes, and glad to know that since Tyndall spoke in Belfast she has made great additions to the knowledge of general molecular mechanism, and especially of synthetic artifice in the domain of organic chemistry, though the more exhaustive acquaintance gained only forces us the more to acquiesce in acknowledging the inscrutable mystery of matter. Our conception of the power and potency of matter has grown in little more than a quarter of a century to much more imposing dimensions, and the outlook for the future assuredly suggests the increasing acceleration of our rate of progress. For the impetus he gave to scientific work and thought, and for his fine series of researches chiefly directed to what Newton called the more secret and noble works of Nature within the corpuscles, the world owes Tyndall a debt of gratitude. It is well that his memory should be held in perennial respect, especially in the land of his birth.

* Abstract of Prof. James Dewar's presidential address before the Belfast meeting of the British Association.

PUMPING PLANT FOR CONDENSING WATER.

THE condensation of steam in the large quantities required in electric power stations is often a difficulty in those cases where a central site is selected. Mr. Charles Hopkinson, in a paper read at the Institution of Mechanical Engineers, states that the discharge of aqueous vapor in large quantities is intrinsically and legally a nuisance. This objection has caused trouble to users of cooling towers, and was the reason for abandoning the cooling-tower scheme as part of the

Newcastle tramway power plant. As an alternative it was decided to pump from the River Tyne, distant some 500 yards horizontally and eighty-six feet vertically from the engine-house, and to utilize the energy of the water flowing back to the river. Accordingly, after the usual formality of the advertisement and reception of bids the system was adopted, designed to supply at present 75,000 gallons per hour, and to be conveniently capable of supplying from 150,000 to 200,000 gallons per hour. The plant consists of three Mather & Platt single-chamber, high-lift centrifugal pumps. These are driven by shunt-wound motors, assisted by turbines on an extension of the pump and armature spindle. In these pumps water enters the revolving wheel axially and symmetrically on each side so that axial thrust is eliminated. The water then traverses the curved internal passages between the veins, and is discharged tangentially at the periphery into a stationary guide ring of special construction. The article is fully illustrated and is supplemented by curve sheets showing the ratio of total head and feet and revolutions per minute, and gallons delivered per minute.—The Electrician (London).

NEW VESSELS OF THE FRENCH NAVY.

LINE-OF-BATTLE SHIP "REPUBLIQUE"; ARMORED CRUISER "JEANNE D'ARC," AND A "CONTRETORPILLEUR."

WHILE the navies of England, Russia, and Germany, in increasing their fleets, have for a number of years been paying attention especially to the construction of line-of-battle ships, France has chiefly occupied herself with the development of her cruiser fleet. For three years no real battleship had been launched in France, so that the recent launching of the "Republique" was regarded with particular interest. This vessel is the first of six first-class line-of-battle ships in course of construction or projected, in which the experiences of the last naval constructions have manifestly been turned to good profit. The other five vessels, all representing the same type, are to receive the names "Patrie," "Democratie," "Liberté," "Justice," and "Verité." Characteristic of these new ships is, above all, the strong battery, which has been given a peculiar disposition. It consists of four 30.5-cm. (12-inch) guns in two large turrets, one of which is installed fore and the other aft on the upper or spar deck. Further on are, on the upper deck, six revolving turrets, each of which contains two 16.4-cm. (6.45-inch) rapid-fire guns. The double turrets for the main battery have been chosen to save weight, since naturally the mounting of the guns in pairs can be accomplished with less weight than in single turrets. The remaining six 16.4-cm. (6.45-inch) guns are installed in single casements at gun deck height. Hence, the value of a uniform fire direction, highly estimated in other navies, has been considered but little, but the more technical advantage of large arcs of command has been utilized. The light battery, composed of twenty-six 4.7-cm. (1.85-inch) and two 3.7-cm. (1.47-inch) quick-fire guns (the latter mounted in the fighting top) fitted throughout on pivot carriages with protective shields, is posted partly on the gun deck and partly on the upper deck. The torpedo armament, finally, consists of five tubes, two above water and two submerged on the broadsides and one above water at the stern. The saving in weight obtained by the double mounting of the 16.4-cm. guns has been utilized for a specially strong protection of the hull. The "Republique" possesses an armor belt extending to a height of 2.5 meters above and 1.5 meter below the water line for the whole length of the vessel, and amidships on the water line the armor has a thickness of 280 millimeters (11.02 inches) which, toward the top, decreases to 260 (10.23 inches) and, toward the bottom, to 180 mm. (7.08 inches). Fore and aft the armor belt has a thickness of 180 (7.08 inches) and 140 (5.51 inches) millimeters, respectively, while a large portion of the remaining hull of the vessel, especially at the bow, is protected by armor 80 millimeters (3.15 inches) thick. The armor protection of the large turrets is fixed at 280 millimeters (11.02 inches), and that of the 16.4-centimeter (6.45-inch) guns at 160 millimeters (6.29 inches).

For the dimensions of the vessels of the "Republique" type, the following data may suffice: Length between the perpendiculars, 133.80 meters; greatest breadth, 24.25 meters; draught, 8.376 meters; displacement, 14,865 tons. Only steel has been used in the construction. The engines will indicate 17,475 horse power, designed to generate a speed of 18 knots. The normal coal supply is fixed at 905, and the maximum capacity at 1,825 tons. The outward appearance of these new battleships is picturesque and unique, the three peculiarly shaped smokestacks and the numerous turrets on the upper deck contributing especially to this effect.

Regarding the powerful armored cruisers of the French navy, which are almost all under construction, the reports are not very favorable, and especially the "Jeanne d' Arc," built as a trial vessel, has not fulfilled the expectations placed in it. This mighty vessel, which has a length of 145 meters (475.74 feet), and a displacement of 11,270 tons, attained at the trial trips only a speed of 18 knots instead of the expected 23 knots. Besides, a number of alterations were found to be necessary as soon as the boat was placed in service, so that the completion is still very remote. At any rate, the "Jeanne d'Arc" is an interesting vessel, and it is hoped that she will not remain the child of sorrow of the French navy. Her engines indicate 28,500 horse power, hence 1,000 more than those of the "Léon Gambetta," launched last year, whose displacement, however, is 980 tons greater. The "Jeanne d'Arc" is built, like the remaining armored cruisers, as a commerce destroyer and, therefore, has a comparatively slight armament. She carries only guns of medium and small caliber, viz: two 19-cm. (7.47-inch), fourteen 14-cm. (5.51-inch), sixteen 4.7-cm. (1.85-inch), and six 3.7-cm. (1.46-inch) rapid fire guns, as well as two torpedo tubes. The chief object in these vessels has been, conformably to their purpose, considerable speed and a large radius of action. Thus the "Jeanne d'Arc" has a maximum coal bunker capacity of 2,000 tons, and is thus able to cover at normal speed a steam distance of 13,500 sea miles, or 25,000 kilometers. The protection of the "Jeanne d'Arc" consists of an armor belt of 152 millimeters (5.98 inches) in the center, and 90 (3.54 inches) and 40 mm. (1.58 inches), respectively, fore and aft. The horizontal, slightly arched armor deck protecting the vital parts of the vessel, extends over the entire length and has a thickness of 55 millimeters (2.17 inches).

The perfecting of the torpedo system of the French navy is incessantly and eagerly pursued by the numerous new constructions; and in accordance with the experience in other navies, France has also endeavored to give the torpedo boats an increased seaworthiness together with a larger displacement. The so-called "contretorpilleurs" conform in size almost exactly to our (German) G and S high-sea boats. The former have a displacement of 303 to 313 tons, the latter one of 350 tons. The construction of the two, however, is quite different, while the speed is almost the same. What strikes one in the French torpedo boats is the superstructure extending nearly over the whole length of the vessel, which, situated about 0.75 m. above the deck proper, has manifestly proved valuable in a rough sea. On this upper deck the guns are also mounted. They consist almost invariably of six 4.7-cm. (1.8-inch) and one 6.5-cm. (2.56-inch) rapid-fire pieces and two torpedo tubes. The 6.5-cm. gun is generally placed on the conning tower situated before the foremost smokestack. Altogether, the French navy possesses 179 torpedo vessels of different kinds, including those approved for construction for 1902.

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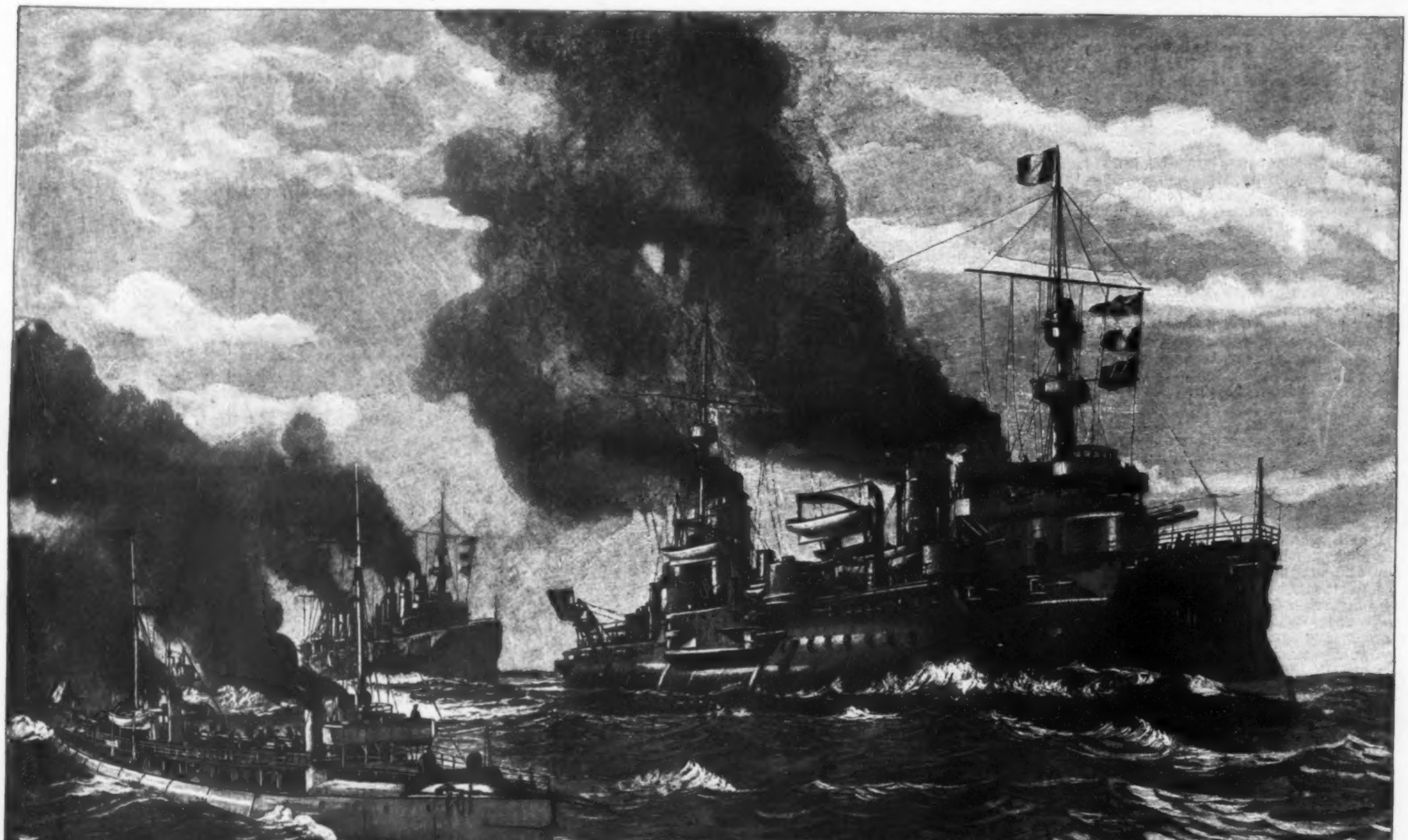


Torpedo boat destroyer of the latest construction. Armored cruiser "Jeanne d'Arc." Battleship "Republique."

NEW FRENCH WARSHIPS.

STATISTICS OF THE SOUTH AFRICAN BRITISH AND AMERICAN TRADE.

THE importance of Africa as a field for the producers and manufacturers of the United States is illustrated by some figures just received by the Treasury Bureau of Statistics showing the commerce of the United Kingdom with Africa. Considerable pride has been felt in the fact that the exports from the United States to Africa have grown to $33,000,000 in the fiscal year 1902, but a comparison of these figures with those of the exports from the United Kingdom to that continent shows that our exports to Africa still form a very small proportion of the importations of the Dark Continent. The total exports from the United Kingdom to Africa, according to figures received by the Bureau of Statistics, were in 1901, $157,000,000, or practically five times as much as the exports from the United States to Africa. While the growth of exports from the United Kingdom to Africa has not been so rapid as in the case of the United States, it has been steady and persistent. In 1897 the total exports from the United Kingdom to Africa were $120,000,000; in 1900, $134,000,000; and in 1901, $157,000,000. Of this exportation of more than $150,000,000 worth of merchandise to Africa, nearly two-thirds goes to the southern part of the continent, the figures being, to Cape Colony, $62,700,000; to Natal, $29,500,000; and to Portuguese Africa, chiefly that section located on the southeastern front of the continent, and forming the most direct entrance to the territory of the late Boer republics, $6,020,000. The next section in importance is Egypt, to which the exports from the United Kingdom are $31,228,000; next, British West Africa, $13,222,000.

An analysis of this market for over $150,000,000

worth of British products shows that the chief exports to Cape Colony consists of cotton piece goods, iron, wrought and unwrought, coal, provisions of all sorts, and manufactured articles, especially apparel and haberdashery. To Natal the exports are similar to those to Cape Colony, with the exception of coal of which a considerable quantity is produced in Natal itself. To Portuguese Africa the shipments included cottons, machinery and other supplies, chiefly for the Transvaal and Orange River Colonies. To British West Africa, cotton goods, coal and iron are the most important articles exported. To Egypt the exportations included cotton goods to the value of $1,086,000; coal, $8,325,000; iron wrought and unwrought, $1,630,000; and machinery, including steam engines, $1,935,000.

The trade of Transvaal seems likely to prove an important factor, especially in view of the present and prospective enlargement of the gold mining operations. For the five months ending with May they amounted to $16,925,000, against $4,185,000 in the corresponding five months of last year. Among the more important articles exported from the United Kingdom to the Transvaal in the five months ending with May are metals and manufactures, including agricultural implements, $3,956,000; apparel, haberdashery, etc., $2,623,000; provisions, exclusive of corn and dairy products, $2,365,000; corn and grain, including flour, meal and rice, $944,000; leather and manufactures, including saddlery, boots and shoes, $812,000; dairy products, $720,000; drugs and chemicals, $642,000; breweries, including ale, spirits, wines and mineral waters, $618,000; wood and manufactures, $574,000. To the Orange River Colony the exports are much less, the figures for the first quarter of 1902 being $1,771,000, against $435,000 in the corresponding quarter of the preceding year.

Cotton piece goods alone form a very important feature of British exports to Africa. In 1897 they amounted to $23,763,000, and in 1901 to $30,381,000. Of this total, $11,300,000 went to Egypt; $6,053,000 to Cape Colony and Natal; $4,672,000 to British West Africa; $3,022,000 to French Africa; and $2,876,000 to Morocco.

The following table shows the total value of exports to Africa from the United States and United Kingdom, respectively in each calendar year from 1897 to 1901:

Year	From United States.	From United Kingdom.
1897	$16,679,427	$120,674,000
1898	18,111,470	118,280,000
1899	18,602,394	119,521,000
1900	22,979,170	134,563,000
1901	29,652,093	157,130,000

THE NATURE OF THE COHERER.

In a note, presented by Mr. J. Fenyi to the French Academy of Sciences, are described the results of an interesting study of a small coherer formed of steel needles. If four of these coherers are placed in parallel they behave as one instrument. This arrangement will work perfectly, provided the potential of the battery does not surpass one-quarter of a volt. With a difference of potential of one volt, it ceases to act. On the contrary, if four of these coherers are placed in series they will work satisfactorily upon a circuit with a difference of potential of one volt. In fact, any voltage can be used successfully by increasing the number of coherers in a proportion of four to each volt difference of the potential in the circuit. The properties of a coherer having only one point of contact can, in a manner, explain the operation of the usual coherer formed of filings or carbon particles. The small particles of metal are placed, as it were, in series. As is well known, the coherer is not a perfect insulator, but allows a small current to pass. There is here a gradual fall of potential from particle to particle, according to their number. These filing coherers can be used in circuits having one or more cells. The behavior of the usual coherer is similar to that of one built up by a series of needle coherers. However, in the first case, the number of contacts is unknown and can not be varied, while by the use of the needles the number of contacts can be anything desired. The use of needle coherers, however, gives the experimenter entire control of the sensibility of the instrument and enables him to secure certain results at all times. It is known that sifting the filings increases the sensibilities of the coherer. The effect, however, is attributed to the dulling of sharp points by this process, and not to the uniformity of size. Needle coherers work satisfactorily even when a fairly large current is passing through them. This property enables the arrangement of the circuits to be very simple. Thus, a coherer having six points of contact, and placed upon an electric bell which is connected in series in the circuit, will operate satisfactorily. The striking of the bell suffices to decohere the needles. By placing a Morse receiver in parallel with the bell an equipment is obtained which can be used satisfactorily for experiment in the laboratory. An arrangement of this kind will also serve to indicate the approach of distant storms. The experience in the use of this apparatus has shown that its sensibility is determined by the length of the insulated conductor.—L'Electricien (Paris).

A NEW CONSTRUCTION OF INCANDESCENT MANTLES.

A PROCESS has been patented in Germany by G. Buhlmann, of Berlin, for burning off and forming incandescent mantles in one operation. The cotton fabric, impregnated with the salts of the rare earths, is placed upon a frame which is exactly of the shape and length, but a trifle smaller in diameter, than the finished mantle has to be. This frame is constructed of wire gauze, perforated metal, or something of the kind, and it has a solid top made of a metal plate. To the inside of the frame is led a gas flame under considerable pressure, or an intensely hot current of air, which by virtue of the baffle plate at the top is made to pass through the holes of the gauze uniformly all round from head to foot. Thus the whole of the mantle is simultaneously ignited, and the decomposition of the rare earth nitrates and of the cotton fiber takes place quickly and evenly all over the surface, the mantle rapidly shrinking in size till it fits the metal frame. At the same time, or afterward, a ring-shaped gas burner, so constructed as to give an annular flame pointing downward, plays upon the head of the mantle, igniting and hardening the supporting collar, etc. Several advantages are claimed for this arrangement; first, a slow ignition of the fabric and decomposition of the salts is said to be prejudicial to the illuminating power of the complete mantle, and Buhlmann's process is stated to be specially quick in operation. Secondly, when the incineration is performed by an outside flame, the mantle is only formed in sections, which tends to set up strains in it due to uneven contraction, whereas the new method heats the whole mantle at once. Thirdly, the process is more automatic than usual, and does not depend so largely upon the personal skill of the operators, as all other methods do.—Engineering.

ELECTRIC WAVES AND THE HUMAN BRAIN.

In a note presented to the Academy of Sciences, Prof. Thomas Tommasina of Geneva reached the conclusion that the human body may be employed as a receiving station in wireless telegraphy.

FIG. 2.—RECEPTION OF SIGNALS BY MEANS OF A WAVE COLLECTOR FORMED OF TWO NEEDLES THRUST INTO A BRAIN.

We ourselves have several times verified Prof. Tommasina's assertion and found that the human body is a receiver almost as perfect as a wire or metallic rod. It is less of a conductor than metal, but, as an offset, presents a wider surface, which practice has demonstrated to be very advantageous for the reception of waves in wireless telegraphy. We have made use of our bodies both as receiving and transmitting stations, first insulating ourselves properly from the ground. We have thus been able to make communications at appreciable distances by sending and receiving the waves through the body (Fig. 1).

Mr. F. Collins, a young electrical engineer of the United States, has gone still further. He has found that electric waves of great frequency, those of certain flashes, for example, act upon the brain of man and animals both before and after death. The brain acts as a coherer, and coheres and afterward decoheres itself automatically. And this is not all: the human body may serve as a complete receiver in wireless telegraphy. Having the receiver and the coherer, we need a battery. This Mr. Collins finds in the nervous system.

In experimenting upon a live cat that had been put to sleep, Mr. Collins and his collaborators, among whom there were some well-known specialists and professors, remarked that the cat jumped up under the influence of the electric waves, just as when it was submitted to an intermittent or alternating current.

It may be admitted that the waves that cause the nerves to approach or recede also cause the passage or interruption of the nervous current of the brain, by producing extra opening and closing currents. The nerves serve as conductors, and the receiver is the face, which, in nervous persons especially, shows the action of lightning by signs of fear.

The following are Mr. Collins' conclusions: (1) The electric waves emitted by the flash act in such a way as to cause the nerves to approach; (2) the cerebral matter acts like a coherer, in life as well as after death; (3) what is often defined as fear is due to the action of electric waves upon the brain; and (4) the electric waves propagated by the disruptive discharge of the flash are capable of producing characteristic accidents followed by death.

Such facts are of interest to wireless telegraphers in particular and to humanity in general.

It results from what has been said that waves of great frequency, which, like X-rays, possess a great power of penetration, should be replaced by those of low frequency obtained especially by the discharge of Leyden jars (Braun system of wireless telegraphy), or, better still, by the alternating current system (without sparks), of which Lieutenant Poncelet and ourselves are partisans. But there is still another standpoint from which we should view Mr. Collins' experiments and results. As the Electrical World remarks, the phenomena pointed out by this gentleman are of a nature to throw light upon the theory of telepathy.

We certainly scarcely expected to see telepathy, or the transmission of thought to a distance, appear here. The remark is merely incidental, but, since scientists have a tendency toward admitting the possibility of this psychic phenomenon, it is of interest to try to explain it. Mr. Collins' experiments give a certain range to this theory. From the experiments that we have just mentioned, it is evident that transmissions from brain to brain can be produced at a distance, just as in wireless telegraphy. One brain sets the nervous waves in action and the other receives the waves, as in the ordinary wireless receiver. Once again we have here a hypothesis, but one which, according to Mr. Collins' experiments, has a certain value.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

THE DETERIORATION OF STORAGE BATTERY PLATES.

In an article printed in the Electrical World and Engineer, A. L. March sums up his conclusions on the deterioration of storage battery plates as follows:

The lead cell has not received enough attention from its chemical and physical side, most manufacturers having paid more attention to mechanical details, and this has given the battery a rather unbalanced development. However, the manufacturers are now giving more attention to the chemistry of batteries, and we may ex-

FIG. 1.—EXPERIMENT IN WIRELESS TELEGRAPHY WITH THE HUMAN BODY AS A RECEIVER AND TRANSMITTER.

pect to see in the near future a considerable improvement in lead cells in the way of longer life and greater reliability.

I think the investigations should be directed to methods for securing greater porosity and firmness in the active material of the positive electrode and to improving the electrolyte so as to prevent the formation of lead sulphate, or at least to render it insoluble in all densities of the acid solution, so that it remains in place and can be restored to the proper condition.

Other metals will undoubtedly come into competition with, and may displace, lead in batteries for traction work, but as an auxiliary in electric light and power stations lead cells will probably hold their own for some time.

Nickel is a strong metal compared with lead. Its peroxide belongs to that class of depolarizers which add electromotive force to the cell, and in this respect it is the best, so far, that it is practical to use in alkaline electrolytes. The electrolyte permits the use of steel for the grids and the containing vessel, and this gives a construction both light and strong. There seems to be no reason to believe that this cell will not do what Mr. Edison claims for it.

Silver would be a good metal to use in traction batteries if its cost were not so great. To be sure, the silver in a worn out battery would go a long way toward paying for a new set, but the first cost would be rather great. Silver is a rather abundant metal, and ought to be produced for much less than it brings at present, if the demand for it should sufficiently increase.

In the lead cell the active material of the positive is only about half of the weight of the entire plate, so the weight or silver oxide required in the silver cell would correspond to the weight of lead peroxide, and not to the whole electrode. The other materials used would be inexpensive; nickel or steel for the positive grid, and probably iron for both negative grid and active material.

Experiments indicate that a silver battery, giving the same power as a lead automobile battery weighing about 550 pounds, would require only about 70 pounds of silver oxide and perhaps less. It would not take a very extraordinary reduction in the price of silver nitrate to make the cell practical from a financial standpoint, and for the reasons given above such a cell could be made to have a comparatively long life and high efficiency, and would require but little attention to keep it in working order.

PHOTO-ELECTRIC EXPERIMENTS.

By A. FREDERICK COLLINS.

THE curious working out of another of Hertz's great discoveries in wireless telegraphy has been exemplified in the recent long-distance test made by Mr. Marconi when he received signals a distance of 2,099 miles from Poldhu, Cornwall, while on board the "Philadelphia."

On this trip it was found that the signals were distinct and clear at night for 2,000 miles, but in the day the effective distance at which the signals could be deciphered was only a fourth part as great, or 500 miles.

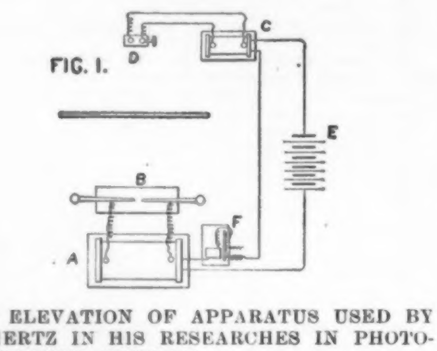
In tracing this effect to its cause, one finds abundant experimental proof that this is a normal and proper result. In 1887 Hertz found that one disruptive discharge on another had the effect of diminishing the spark of the latter, and upon careful analysis he determined that this untoward result was due to the ultra-violet radiation—in which the disruptive discharge is rich—dissipating the charge of the secondary oscillatory system.

The apparatus Hertz employed in his researches is shown in Fig. 1. It consisted of an ordinary Ruhmkorff induction coil, *A*, connected with an oscillator system, *B*; a second and smaller induction coil of the same type, *C*, having a very small spark gap, *D*, was set parallel with the larger coil, with the spark gap of both in alignment, so that the radiating properties of either coil will be such that the spark gap of the other will be in the best position to receive the waves. The primaries of both coils are connected in series with a battery, *E*, and an interrupter, *F*, both of which are common to and suffice for both coils.

When the spark gap, *B*, was screened from that of *D* either by a conductor or an insulator, i. e., a metal or ebonite plate, the spark discharging across *D* became much smaller. It was this fact which first excited Hertz's interest in the experiment; and in solving just such complex phenomena as this in speculative physics is where his marvelous analytical genius was shown most splendidly. Had the spark been diminished by the intervention of the conductor and not the insulator, or *vice versa*, then the explanation could have been easily traced to electro-magnetic or electrostatic displacements, since there was a synchronous action between the coils, being operated on a common circuit, but where both insulator and conductor produced the same effect, reason proclaimed the retardation of the spark due to waves emitted directly from the spark of one falling on the other oscillatory system. It was reasonable to suppose that these were light waves. To test the validity of this supposition, Hertz arranged the oscillatory system separate and the result was the diminishing of the spark as before. This the physicist attributed to the dissipation of the electric charge on the balls of the oscillator. The diselectrification of the charge on metals by light waves or rather radiation has been termed *photo-electric* action; and since Hertz the phenomenon has claimed the attention of some of the leading physicists. Hertz's researches were exhaustive in so far as the photo-electric effect of one spark on another was concerned. He tested the influence of sparks between knobs, points, and other forms of terminals forming the spark gap; he employed short, straight sparks and long, jagged sparks, the faintly luminous blue sparks, and the brilliant white sparks; he found that sparks of only 2 millimeters in length possessed the property of diminishing the secondary electric sparks at a distance of 15 or 20 centimeters.

Hertz showed that glass cuts off the photo-electric effect and this led him to suspect that it was not the visible waves of light that possessed the photo-electric property, but the extremely rapid invisible ultra-violet radiation. When the glass tube allowed the minutest spark to be exposed at either terminal the effect was instantly reproduced. The maximum effect was obtained by short sparks between balls of different metals. Oscillatory balls of different metals were tried, but Hertz found no appreciable difference; the only conditions seemingly to be fulfilled were perfectly clean and polished sparking balls with the sparking distance not too great.

Naturally, as Hertz pointed out, the relation of the primary and secondary sparks was reciprocal, the disruptive discharge of one acting on the disruptive discharge of the other. In further demonstrating that

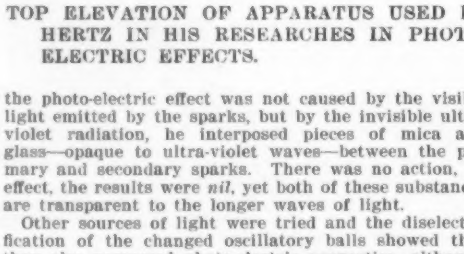


TOP ELEVATION OF APPARATUS USED BY HERTZ IN HIS RESEARCHES IN PHOTO-ELECTRIC EFFECTS.

the photo-electric effect was not caused by the visible light emitted by the sparks, but by the invisible ultra-violet radiation, he interposed pieces of mica and glass—opaque to ultra-violet waves—between the primary and secondary sparks. There was no action, no effect, the results were *nil*, yet both of these substances are transparent to the longer waves of light.

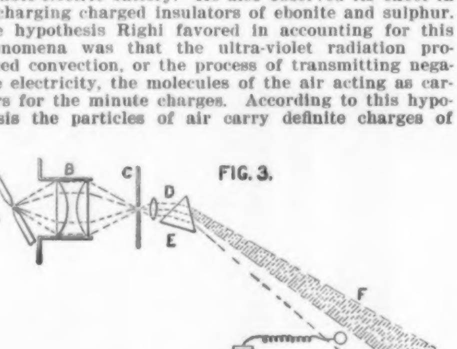
Other sources of light were tried and the diselectrification of the changed oscillatory balls showed that they also possessed photo-electric properties, although the faintly luminous spark of the induction coil was a great deal more effectual since it is a much richer source of ultra-violet waves. Hertz tested the sunlight for photo-electric effects many different times of the day and seasons, but without result, and this lends the greater interest to the recent experience of Marconi.

After Hertz, Prof. Auguste Righi—the preceptor of



RIGHI'S APPARATUS FOR SHOWING PHOTO-ELECTRIC EFFECTS.

Marconi—took up the work and his researches resulted in demonstrating that the greatest photo-electric effect was produced by an arc light, the electrodes of which were formed of rods of zinc; in accordance with Hertz, Righi was unable to discover the slightest influence exerted by the sun's rays. Righi found that the charge of copper gauze and zinc plate would be reduced under the radiation of ultra-violet light, and with a number of elements so formed, he constructed a photo-electric battery. He also observed its effect in discharging charged insulators of ebonite and sulphur. The hypothesis Righi favored in accounting for this phenomena was that the ultra-violet radiation produced convection, or the process of transmitting negative electricity, the molecules of the air acting as carriers for the minute charges. According to this hypothesis the particles of air carry definite charges of



LODGE'S APPARATUS FOR SEPARATING THE ULTRA-VIOLET RADIATION FROM THE VISIBLE LIGHT WAVES.

negative electricity, and when these traverse certain paths they cast electric shadows, just as they do in a Crookes shadow tube. Righi determined that an insulated metal is charged to the *positive* sign by ultra-violet radiation, that is if the metal is neutral or has a small initial plus-charge at the beginning of the experiment. By employing a more sensitive method of detection than Hertz, Righi found the discharging effects of photo-electric radiation for negative electricity greatest when the spark gap was formed with terminals of zinc or aluminium. Righi assumed the reason for the failure of sunlight to produce photo-electric effects to the absorbing action of the atmosphere for ultra-violet radiation. In the light of later research it is evident that the sun produces a very appreciable action, but that sensitive instruments are required to detect it. In reproducing these experiments, an easy and effectual method may be contrived with little trouble, but exceeding care must be taken in making the tests.

Fig. 2 shows the arrangement of the apparatus. *A* is an arc-light formed of zinc rods, *B* a gold-leaf electroscope to which a ball of polished zinc, *C*, is attached by a wire. Let the ball be charged with negative electricity, and then expose it to the rays of the arc lamp; almost instantly the leaves of the electroscope will converge, showing that the charge is dissipated; but let the ball be charged positively, and the experiment reproduced; it will be found that no appreciable decrease of the charge takes place.

To demonstrate more clearly that this discharging effect is due to the action of the invisible ultra-violet rays, Lodge used the combination of apparatus as shown in Fig. 3. *A* represents the zinc-rod arc-lamp, *B* a pair of plano-convex condensing lenses of quartz, *C* a diaphragm, *D* an objective convex quartz lens, and *E* a quartz prism. The shaded portion, *F*, shows the path of the visible rays, and the unshaded portion, *G*, inclosed in the dotted lines, represents the invisible ultra-violet radiation. Now the instant the negatively charged zinc ball is placed in the line of the ultra-violet radiation, the phenomenon of photo-electric action is apparent, the drop of the leaves of the electroscope showing the charge has been carried away.

While Hertz and Righi failed to observe the photo-electric effects of sunlight, Elster and Geitel succeeded, and have been able to exhibit not only the dissipating influence of the direct rays of the sun, but of diffused daylight. The apparatus with which this experiment was accomplished consisted of a zinc dish 20 centimeters in diameter and well insulated; this was connected to a quadrant electrometer and charged negatively, in the dark, to a potential of 300 volts, when it was exposed to the action of the sunlight; the test showed a drop in voltage to 0 in 60 seconds, whereas a positive charge was retained for a very long time. The leakage of negative electricity from the dish when in the dark was practically eliminated. Diffused daylight also produced an appreciable drop in potential.

There are many other experiments in photo-electric action relating to the checking of magnetism on the dissipation of an electric charge in rarefied gases, on the diselectrification of minerals by sunlight, et cetera, in which, however, vacuum tubes play important rôles, but these, while interesting, have no bearing on the subject of photo-electric action in wireless telegraphy, at least at the present time. It has been shown that silver and copper plates require a much stronger ultra-violet radiation before any dissipating discharge takes place than the other metals, while zinc and aluminium have a photo-electric sensibility even for blue light.

It would seem then that the antennæ in wireless telegraph installations could be insulated with a glass sheath, which would cut off the ultra-violet radiation; or that if copper were employed for the sending and receiving antennæ, the dissipation would be very much reduced. It would be an interesting experiment to ascertain just what effect a shield capable of cutting off the ultra-violet radiation would have upon commercial wireless telegraph apparatus. At all events, it is evident that oceanic cableless telegraphy will be productive of some wonderful modifications in the present forms of wireless telegraph apparatus, and that mountains will take the place of the mole-hills when apparatus is constructed to transmit a cableless message a distance of 2,000 miles instead of the short distances covered by miniature laboratory sets that have already developed such phenomena as photo-electric effects.

THE SAFETY MATCH PROBLEM.

THE city of New York intends to make the use of safety matches compulsory. So far only the Fire Department's view of the case has been presented in the public press. The opinion of a match manufacturer, Mr. William E. Williams, of Chicago, Ill., may, therefore, not be without interest.

Mr. Williams says that in the matter of the dangers attending the use of parlor matches there is much superstition. Many people believe that mice will eat the heads of parlor matches and thereby ignite them. The only material in the head of a match which is worth eating, is the glue; and glue is not inviting when compounded with ground glass, flint and foul-smelling chemicals. Animals have a particularly fine sense of smell. For that reason they avoid matches. No one, says Mr. Williams, ever heard of a mouse's eating glued furniture, or gnawing a crack in furniture in order to get at whatever glue might be contained therein. And yet all furniture is put together with glue. He tells us that he had a desk drawer almost filled with sample matches of all kinds. Attracted by the remains of a lunch that had been hidden in the drawer by an office boy, the mice entered and gnawed a passage between the boxes of parlor matches. The pasteboard of the match boxes was completely gnawed away; and yet the match heads were not ignited.

In the matter of accidental ignition of a parlor match, Mr. Williams points out the well-known fact that the noise produced always gives the alarm. Any safety match will ignite by heat and by friction. No noise is produced.

Economically considered, Mr. Williams holds that the parlor match is far cheaper and better than its rival. He claims that it takes about four times as long to get a light from a safety match. Furthermore, safety matches of necessity are packed in small boxes holding on an average not more than 35 matches, while for a parlor match 200 matches and over constitute the average box. The box for the safety matches is heavier and more expensive. Safety matches, says Mr. Williams, are of necessity packed in small boxes and are always accompanied by the box. Furthermore, the manufacture of parlor matches in the United States has advanced to such a stage of perfection that foreigners can no longer compete with us; but in the manufacture

of the safety-matches the foreigner excels us. Almost all the matches imported into this country are safety matches.

The origin of but very few of the fires annually recorded is positively known. No doubt the parlor match is charged with having started many a fire that may more properly be attributed to another cause. In Mr. Williams' opinion cigar, cigarette and pipe sparks, as well as burning stumps, probably cause the greater number of fires.

THE PARADOX OF THE PANTHEON.

The Romans were the first people to realize the artistic value and develop the architectural possibilities of the groined vault and dome. By their means they obtained effects of unencumbered spaciousness impossible with columns and piers. Greek buildings remain to our day only as roofless ruins. The stupendous monuments of Egypt, rivaling those of Rome in magnitude, are chiefly open courts and colonnades with hypostyle halls, which, though roofed with stone, are encumbered by columns. In the Great Hall at Karnak the broadest aisle is less than 20 feet wide in the clear and not over 80 feet high. In contrast with these dimensions are those of the Baths of Diocletian at Rome, which have an unencumbered floor space of 340 by 87 feet, with a groined vault 90 feet high. The constructive methods by which the Romans accomplished the erection of these great buildings have been investigated by many architects, and are the subject of several valuable books. A systematic study and examination of Roman vaulting has never been undertaken, however, and in the most perfectly preserved and frequently visited of all Roman monuments, the Pantheon, the extraordinary contradiction between the construction and decoration of the magnificent dome, though known for 150 years, has hardly been discussed. In 1894, Professor A. D. F. Hamlin, of Columbia University, observed certain facts which suggested a surprising explanation of this paradox, and after waiting in vain for some years for a solution from some other source, has discussed the subject in a series of papers in the School of Mines Quarterly, from which the following notes, says the Engineering Record, have been abridged with his permission. As a study in ancient Roman vault construction, apart from the Pantheon problem, the papers also merit the attention of all interested in the engineering and architectural methods of bygone days.

The true Roman system of construction is particularly interesting at the present time because it was based on the use of concrete. The architecture of the Egyptians and the Greeks was one of stone, and the construction of their great edifices was a tedious labor. When Rome, enriched by the spoils of worldwide conquests, began to build on a grand scale, the slow processes of stone construction were out of the question. She had enormous resources as respects rude labor, and the practical Roman builders accordingly devised a system of construction utilizing this unskilled labor to the utmost, employing the relatively limited artistic resources of the empire so as to make a minimum of original design serve for a maximum of buildings. Hence the greater part of the walls, piers and vaults were concrete, and brick and stone were used only for facings.

The builders were economical in many respects. To support the enormous weight of the heavy concrete vaulting while it was setting would have involved a massiveness of timber construction for centerings which was deemed extravagant, and two other methods were adopted to accomplish the same end. Sometimes, over a very light wooden frame covered with slats a couple of feet apart, there was built a thin vault of large flat tiles laid in strong cement. These were covered in turn with smaller tiles breaking joints with the layer below. This made a strong elastic shell, which when loaded up to the haunches with concrete, was quite sufficient to carry the load of the concrete afterward placed on the upper portion to complete the vault. The second method of construction, used in the larger vaults, was more complex. Cellular ribs of brick and tile were first built on light centers. Other centers were then fixed between the ribs, and the intervening space was filled with concrete. As these fillings, starting from the spring and growing a foot or two daily, hardened, they formed monolithic lintels between the ribs, bracing them against lateral overturning, and taking upon themselves a part of the weight of the next portion of the filling.

It is noteworthy that these admirable building methods eventually degenerated into matters of unthinking routine, and there are ribbed vaults where the ribs could have served no useful purpose. Even the Pantheon dating from the early part of the second century is full of solecisms. Lanciani declares that the beautifully executed discharging arches which are so noticeable in the upper part of the exterior brick facing are only one brick deep, and serve no constructive purpose. In the dome of this building the constructive ingenuity of the Romans appears highly developed and yet associated with the most extraordinary disregard alike of that economy of means and labor which characterizes many phases of Roman building, and of the logical connection which in most great architectural works exists between the structural framework and the decorative dress. In the dome of the Pantheon these are not merely independent but are absolutely contradictory.

The Pantheon was built by Hadrian between 117 and 138 on the site of an earlier temple constructed by Agrippa. The portico is a reconstruction by Septimius Severus and Caracalla with materials from an older structure. The building is a circular edifice 142 feet in diameter, internally covered by a hemispherical dome 140 feet high, springing from the circular wall. This wall is 20 feet thick, but its seeming massiveness is reduced one-half by seven niches opening inward, and alternately rectangular and semicircular in plan, an eighth opening forming the great doorway, and eight smaller semicircular chambers opening outward only through small windows. The eight large niches are capped by arches and half-domes. The wall appears to have been constructed in the usual way with facing of broad flat bricks and a filling of pozzolana concrete. The dome is sprung low enough to be inscribed within the square of 142 feet. The 28-foot oculus or eye at the summit not only lights the interior in the most beautiful manner imaginable, but relieves the dome of a great weight at its weakest point, while the carrying up of the exterior drum to one-third the height of the dome, and the series of external steps encircling the dome above it, provide for the loading of the haunches of the vault in the most satisfactory way.

Very effective, also, and admirably simple is the interior paneling of the dome with 140 plain rectangular coffers, each showing four sinkages except in the panels of the upper or fifth tier, which have but three. The lower rails in each panel are wider than the upper ones in order to render them visible to a spectator on the floor of the temple. The paradox of the Pantheon is to be found in this interior paneled face of the vault.

The use of panels as a ceiling decoration lent itself readily to Roman methods of vaulting with brick ribs, which could be arranged to form the vertical members of the framework of the panels, while the horizontal members or rails could likewise be built of brick, forming a rectangular network of bricks sufficiently rigid when set to carry of itself the concrete filling and backing of the vault. But as a matter of fact few large vaults remain which show this system of construction. The great vault of Diocletian's Baths, now the church of S. Maria degli Angeli, is quite smooth and plain internally. Others, like the vaults of the side chambers of the basilica of Maxentius and Constantine, are adorned with polygonal panels, large octagons and small squares or other like combinations, which contradict any practical system of structural ribs. The one complete and monumental example of this kind of vault decoration is the Pantheon, and here, if anywhere, it would seem to be the natural thing to allow the ribbing of the vault panels to dictate the design of the structural framework of the dome. The interior aspect of the dome would naturally suggest a system of vertical ribs converging to the oculus, and a series of horizontal arches between them, framing the panels and stiffening the whole skeleton. But this is not at all the way the dome was constructed, and unfortunately it is impossible at present to say clearly how it was built.

The discordance between the lines of the paneling and the structural skeleton of the dome was first observed during repairs executed between 1743 and 1756, when an architect named Piranesi was enabled to study the construction. His drawings show a framework of eight discharging arches over the eight niches or chapels, supporting eight massive ribs springing from their crowns and braced against disruption under this heavy load by a second tier of arches sprung from the haunches. This system of arches and ribs, harmonizing with the general plan of the wall below, was generally accepted by students of Roman art until recently. The fact that its lines cut across those of the panels and that an eight-fold system is fundamentally inharmonious with one of twenty-eight parts, was of course patent to the most careless observer. But this did not discredit Piranesi's presentation of the structural framework of the dome, because this, if inharmonious with the paneling, was perfectly consistent with the eight-part design of the whole interior, and the paneling was generally considered as a decorative appliqué of ribs in relief, presumably in concrete or stucco, on the inner surface of the completed vault, as shown in Piranesi's cross-sections.

This explanation of the construction of the dome was questioned by Viollet-le-Duc in his famous "Dictionnaire." He suggested a preliminary skeleton of twenty-eight ribs and four series of horizontal arches, all of brick, light enough to be carried by trussed centerings; these formed the paneled design of the inner surface of the dome and served as a permanent centering for the construction of a more massive outer shell of arches and ribs after a modification of Piranesi's system. But this was merely a clever speculation of the French architect and has no basis in observed facts.

Prof. Josef Durm, in his "Baukunst der Römer," discredits Piranesi's scheme by claiming that the latter could have discovered the ribs and arches only by cutting through the exterior cornice and steps around the base and haunches of the dome, and that, as there is no evidence of this, "one may be led to the conclusion that Piranesi was entertaining his readers with a figment of his own imagination." Durm accepts, however, the theory of two shells and two superposed frameworks, but he suggests that there are fourteen and not eight ribs, and that they are sprung directly from the wall and not from the discharging arches. He seems to have overlooked the fact that in harmonizing the framing and paneling he has thrown the framing and the walls supporting it out of accord. Moreover, it hardly seems likely that Piranesi would entirely invent his system at a time when the evidences of his fraud would be so entirely patent to other observers.

From a study of these data and theories, which he gives more completely in his papers, Prof. Hamlin reached the conclusion that Viollet-le-Duc's assumption of two shells was reasonable, although without insisting on the order in which they were built. It was possible that the outer or Piranesi shell was built first and the paneled framework laid up afterward, on the removal of the great centerings for the outer shell, by means of movable centerings hung from the outer framework. Each zone of the paneling would be self-sustaining as soon as completed. If thus constructed as an afterthought, perhaps when Septimius Severus rebuilt the portion, its discordance with the divisions of the dome framework is easier to understand. It was with this theory in mind that Prof. Hamlin examined the dome in 1894. Two years earlier, M. Chédanne had removed the stucco from three panels of the lower row in the dome and from several small areas near these. These bare spots were examined with an opera glass, as there was no scaffolding from which a close examination could be made at the time, and it was clearly seen that the whole structure was brick, ribs and filling alike. But the singular fact became apparent that it was not composed of structural ribs laid up as such according to the theories of Viollet-le-Duc and Durm, but the paneling was formed in the substance of the massive dome of brick, with discharging arches cutting at haphazard across the panels. The theory of a double shell, as well as that of paneling in concrete added as an after-thought, was thus disposed of. The dome was a single massive vault of solid brick, an unusual construction in Rome; the paneling was formed in the brickwork itself and this brickwork was laid up in a series of discharging arches, for a part of its height at least. These were plainly seen to have been planned with reference to the chapels or niches below, and so far, at least, Piranesi was proved to have been correct.

But these facts merely shifted the puzzle, they did not solve it. The inherent contradiction between the twenty-eight panel ribs and the eight-fold design of the rotunda was not explained, it was accentuated. The 140 panels were a part of the dome itself. The only explanation of the contradiction to the satisfaction of Prof. Hamlin is that the paneling was a decorative embellishment of the dome, which was originally intended to present a smooth internal surface, and that the panels were hewn in the solid brickwork after the completion of the vault. Prof. Hamlin acknowledges that such a procedure is contrary to the assumed method of Roman construction; but the alternative solution, that the panels were formed during the laying up of the various discharging arches, assumes the use of molds and of complicated special shapes of brick far exceeding the capabilities of Roman masons at the time this work was done. In Prof. Hamlin's papers he explains in detail the intricacy of the masonwork necessary in laying up the relieving arches and their filling over the huge forms for the panels.

If the dome is supposed to have been built first, with or without a skeleton of arches and structural ribs extending through its whole thickness, and without regard to interior decoration, it becomes clear that this could be done with relatively light and simple trussed centerings. Chédanne has shown from his examination of the brickwork that the eight discharging arches are built like vertical arches, although with the inner faces shaped to the curve of the dome. If this is also true of a second row of arches, as in the Piranesi theory, all the lower part of the dome could have been built up nearly to half its height without centering. As a matter of fact, Piranesi's sections show all the masonry of the dome up to the level of the fourth row of panels laid up in horizontal courses, and with this Chédanne's observations agree. From that level it was possible to erect the eight massive ribs and the oculus at the top on skeleton centerings, spanning the opening with trusses either resting on the completed zone or supported from the floor of the rotunda. Prof Hamlin describes a part of the dome carried up in this manner; he does not claim that this was done, but merely suggests that such a procedure was possible and comparatively simple if the builders did not concern themselves above the interior paneling. The dome being completed and the centerings removed, wholly or in part, the hewing of the panels subsequently would be a simple matter without endangering the stability of the vault. The work would be simple, within the ability of laborers of little or no skill, and remarkable only for its quantity and not its difficulty. That the panels were formed in this manner is the more credible because it allows the supposition that the interior decoration was designed quite independently of the construction.

But two objections have been advanced against the validity of this theory. Chédanne has reported that the surface of the bricks does not indicate cutting. But Prof. Hamlin finds it easier to believe Chédanne mistaken in his observations on this point than to suppose the arches could have been built into the molds without cutting or breaking the bricks; in most cases, he states, it would have been an absolute impossibility. On the other hand, the rough hewing of the panels, to be finished afterward in stucco, might in many places have exposed such a serrated surface as Chédanne appears to have noticed, where the ends of brick came close to the hewing line.

The other argument is the fact that in the center of each panel there is a bronze anchor set in the brickwork to hold a bronze rosette or other ornament. It is not impossible that these were set in the brickwork after its completion, as such an operation is common enough in modern work. But even were this not so, it would simply prove that the paneling had been conceived and provided for when the dome was first built, without at all proving that the panels were actually shaped in the extremely difficult manner suggested by M. Chédanne.

Evidence of the most valuable nature as to the merits of these various explanations of the paradox of the Pantheon could be drawn from the appearance of other buildings of like character, but the present state of knowledge of the details of the vaults from the time of Hadrian to that of Constantine is inconclusive. Only by a critical examination of these structures can the true history and chronology of paneled vault decoration be worked out. Prof. Hamlin gives illustrations of a few examples of such paneled vaulting in which the work is considered to support his theories. The summary of his investigations and studies he states in the following words:

"To sum up the conclusions which appear most rational, taking into account the present unsatisfactory character of the evidence at hand, or at least its lack of final conclusiveness, it would seem probable that the dome of the Pantheon as constructed in the time of Hadrian was internally a smooth vault, as its upper part always remained, and as many great vaults aften were, e. g., the great vault of the Tepidarium of Diocletian's Baths, now the nave of S. Maria degli Angeli. At some date subsequent to its completion, and very probably in the time of Septimius Severus, who rebuilt the great portico of the temple, or of Caracalla, it would appear that the emperor, desiring to embellish the dome and to replace its faded or ineffective stucco decoration with something more permanent and dignified, caused the existing panels to be hewn as a part of his work of general restoration and improvement. Owing to the difficulty and danger of working from overhead in the nearly flat central field of the dome, this work was confined to the lower three-quarters of its surface. It was a work easily executed when once the scaffolding was erected. No indications of the in-

ternal structure, discharging arches or ribs appeared upon the stuccoed surface of the dome. The designer concerned himself, therefore, with only two problems—to secure an adequate scale in his work and to arrange so that the panels should center over the four axial niches of the building. The resultant of these two considerations was the adoption of a scale or spacing giving six panels intermediate between those centered on the axes of the building. The panels were marked out on the plastered surface and the cutting begun, the hewing away of portions of the discharging arches of the dome being a relatively unimportant incident of the work. The beveling of the lower reveal of each sinkage of the panels was a very simple detail of the cutting, although it would have caused infinite labor and trouble to execute upon a mold as suggested by M. Chédanne. When the hewing was thus completed the whole was once more stuccoed, moldings were run in the stucco of the edges of the 140 panels, the central rosettes and adornments of gilded bronze were added and the work was completed.

"The final proof or disproof of this theory must rest upon further and more minute investigation than has yet been possible, both of the Pantheon itself—to the unraveling of whose complicated history Mr. Chédanne has made so important a contribution—and of other vaulted structures of the Roman imperial epoch. The Piranesi system must be finally vindicated or disproved by a more complete examination of the dome than has so far been undertaken. The brickwork of this and other monuments must be examined for technical evidence as to its having been hewn or laid up to a mold. It is to be hoped that the labors of the Italian government, whose Direzione Generale delle Antichita watches with such zealous and intelligent guardianship over its priceless archæological possessions, and the investigations of archæologists and students, both Italian and foreign, to whom the government shows such considerate hospitality, may at no distant date finally and authoritatively elucidate the paradox of the Pantheon."—The Architect and Contract Reporter.

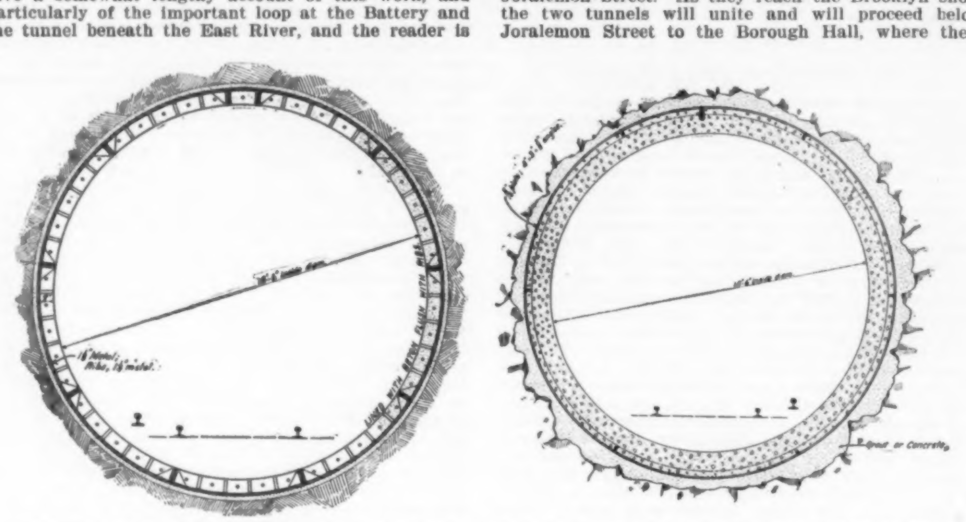
THE MANHATTAN-BROOKLYN BRANCH OF THE RAPID TRANSIT SUBWAY.

From the very inception of the New York Rapid Transit Subway scheme, it was realized that, however extensive the subway on Manhattan Island might be made, it was necessary to the realization of its full value that the system should be carried to Brooklyn by means of a tunnel below the East River. It was only the lack of funds that prevented this extension from being included in the first contract; for the debt limit imposed by the city's charter rendered it impossible to carry out the whole scheme at once. Consequently, when the first contract, including a four-track road from the City Hall Park to 104th Street, with two two-track branches beyond that, was first undertaken, the construction of the subway from City Hall Park below Broadway to the Battery, and by way of a tunnel to Brooklyn, was left in abeyance until the borrowing powers of the city should be sufficient to allow of the latter extension being carried through.

This work has now been contracted for, and the preliminary operations are well under way. The contract was secured by the same company, the Subway Construction Company, that has the first contract now in hand; and just here it may be mentioned that progress on this work has been so rapid, that the Subway Company hope to have the cars running by the first of January, 1904, or some nine months before the contract date for completion. Unless unforeseen difficulties arise, it is likely that the Brooklyn extension will be completed in about three years' time, and that the portion of it lying on Manhattan Island, that is to say the line from City Hall Park to the Battery, will be completed in about a year and a half.

In the current issue of the Scientific American we give a somewhat lengthy account of this work, and particularly of the important loop at the Battery and the tunnel beneath the East River, and the reader is referred to that article for a general description of the work. We present herewith certain drawings reproduced from the contract drawings accompanying the specification which show some interesting details of the construction. The new line starts at the intersection of Park Row and Broadway and, after running down this thoroughfare for one block, it enters the Fulton Street station, which will extend for the length of one block to Dey Street. Six blocks further south will be another station, located at the intersection of Rector Street and Broadway, and a third station at Battery Place adjacent to the Washington Building, No. 1 Broadway. Here the line will swing over to the westward, skirting the edge of Battery Park, and after proceeding a few hundred feet, it will describe a broad loop of easy radius, the point of curve being situated opposite the center of the westerly front of the new Custom House. The curve will begin with a radius of 1,200 feet, and sharpen with a radius of 780 feet into a minimum curve, around the southerly end of the loop where the station will be situated, of 191 feet. There will be two tracks down Broadway, and around the loop, the track on the outside of the loop serving for the through traffic, and the inner track being used for the storage of trains. At the point of the loop another tunnel will be carried on a broad curve, and on a descending grade through the loop itself, and as it approaches the South Ferry station it will separate into two tubular tunnels. The grade will be such as to carry these tracks below and clear of the floor of the South Ferry station, and the two tubes will descend on a grade of 3.1 per cent to a point below the center of the East River, from whence they will rise on the same gradient and pass beneath Brooklyn at Joralemon Street. As they reach the Brooklyn shore the two tunnels will unite and will proceed below Joralemon Street to the Borough Hall, where there will be a station. From the Borough Hall the tunnel will pass below Fulton Street and Flatbush Avenue to the intersection of Flatbush Avenue with Atlantic Avenue. There will be stations at Hoyt Street, at the entrance to Flatbush Avenue, and at the intersection of Flatbush with Atlantic Avenue.

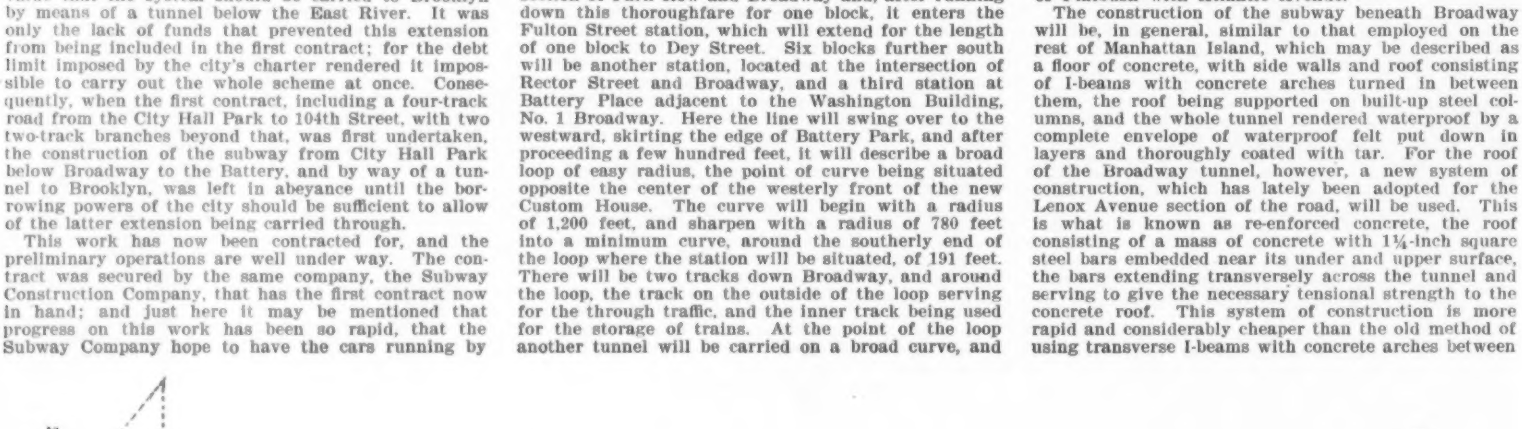
The construction of the subway beneath Broadway will be, in general, similar to that employed on the rest of Manhattan Island, which may be described as a floor of concrete, with side walls and roof consisting of I-beams with concrete arches turned in between them, the roof being supported on built-up steel columns, and the whole tunnel rendered waterproof by a complete envelope of waterproof felt put down in layers and thoroughly coated with tar. For the roof of the Broadway tunnel, however, a new system of construction, which has lately been adopted for the Lenox Avenue section of the road, will be used. This is what is known as re-enforced concrete, the roof consisting of a mass of concrete with 1¼-inch square steel bars embedded near its under and upper surface, the bars extending transversely across the tunnel and serving to give the necessary tensional strength to the concrete roof. This system of construction is more rapid and considerably cheaper than the old method of using transverse I-beams with concrete arches between



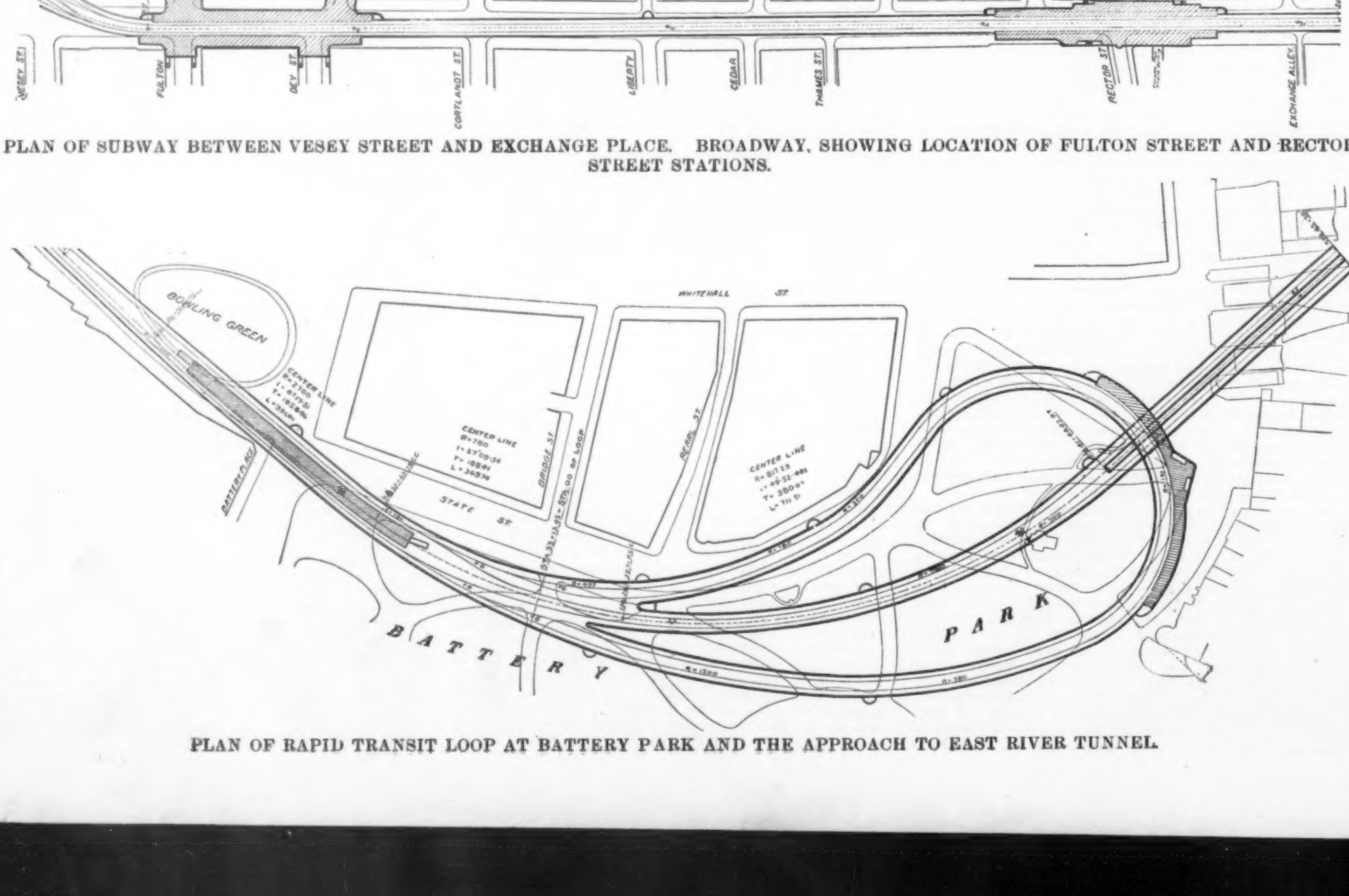
SECTION IN EARTH, GRAVEL, ETC. CAST IRON SHELL LINED WITH BETON.

SECTION IN ROCK. STEEL SHELL LINED WITH CONCRETE.

TYPICAL SECTIONS OF EAST RIVER SUBWAY TUNNEL.



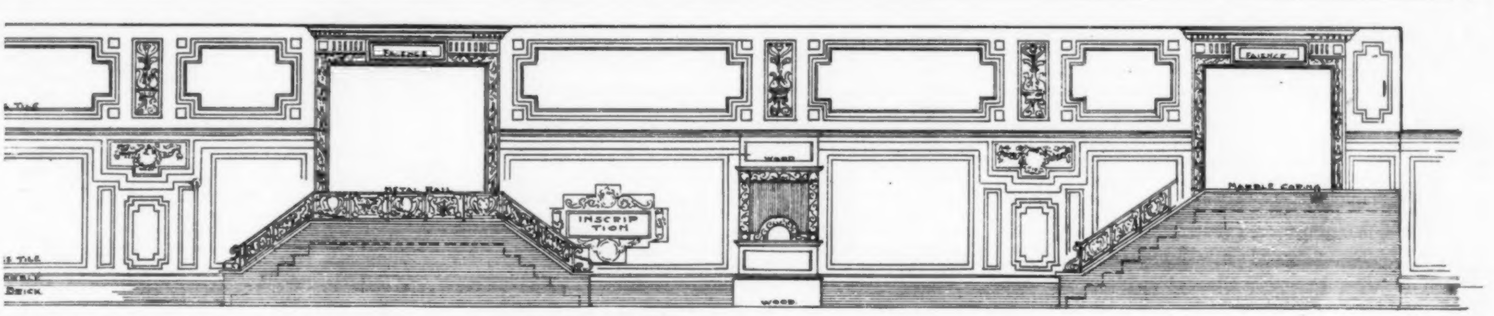
PLAN OF SUBWAY BETWEEN VESEY STREET AND EXCHANGE PLACE. BROADWAY, SHOWING LOCATION OF FULTON STREET AND RECTOR STREET STATIONS.



PLAN OF RAPID TRANSIT LOOP AT BATTERY PARK AND THE APPROACH TO EAST RIVER TUNNEL.

them. The vertical I-beams of the side walls will be retained in building the road down Broadway, as they will prove valuable in affording lateral support for the careful shoring, which must be done in taking care of the foundations of adjacent lofty buildings during the process of excavation.

We present a cross section of the Rector Street station, showing the method of supporting the roof and constructing the platforms and stairways. It will be noticed that at this point the I-beams are retained in building the roof, and that the load is carried by a central line of built-up steel girders and two lateral lines of circular, cast-iron columns, the latter extending down the platforms. The lighting of the station by day will be done by using, wherever possible, in the roof of the stations what are known as vault lights, the lenses of which will be about three inches in diameter and set in cement. The internal appearance of the stations will be made as bright and artistic as possible by ceiling the whole interior with glazed tiles, the tiling being laid on in panels, as shown in the accompanying illustration; and an effort will be made to break up the wall space as much as possible, and render its appearance warm and attractive by a judicious selection of color, green and white predominating. We present also two sectional views of the tubular construction beneath the East River. Where the tunnel has to be driven through solid rock, a steel shell will be inserted and riveted up as the excavation is made, and the interior of the shell will be lined with 15 inches of concrete, the space between the outside of the shell and the adjacent rock being filled in with concrete and cement grouting. Where the tunnel passes through earth, sand or gravel, the shell will be built up of segmental, cast-iron plates, with heavy interior ribbing; and the interior will be lined with beton flush with the inside edges of the ribs, the space between the outside of the shell and the surrounding material being grouted up. The section of the new line lying beneath Brooklyn will be built of reenforced concrete as described above.



INTERIOR OF A RAPID TRANSIT SUBWAY STATION, SHOWING STAIRWAYS, TICKET OFFICE AND THE GENERAL SCHEME OF GLAZED TILE WALL DECORATION.

WOOD-PAVING.*

TREATED wooden-block paving has been used in London for over thirty years on both her finest and most heavily traveled roadways. Paris has nearly four times as many square yards of it in use as of asphalt. There had been laid in 1891, 484,000 square meters and in 1898, 1,165,000 square meters of wooden blocks, there being at that time 382,600 square meters of asphalt and 1,348,000 square meters of macadam.

Foreign growths of wood are, however, practically prohibited for use in America by reason of their large cost. To produce a pavement at moderate and justifiable expense a native wood must be used, so treated, if possible, as to harden its fiber, make it practically impervious to moisture, and not readily susceptible to the varying conditions of heat and cold. There is no gage of durability by which the attempts to produce such results can now be judged. Practice has not yet demonstrated in this country what our natural products can create in the way of a permanent pavement of this character.

There were laid last year in Boston for experimental purposes, in the midst of the otherwise asphalted surface of a busy but lightly trafficked thoroughfare, two small areas of wooden blocks, 1,360 yards in all, treated by the so-called creo-resinate process. These areas are laid in the steepest grades thereof, and in one case for only half the width of the street, the other half being of asphalt that the relative merits of the two might be compared.

This pavement was prepared and laid in the following manner:

The blocks were uniformly 4 inches wide, 4 inches deep and 8 inches long, of long-leaf Georgia yellow pine, free from sap, loose or rotten knots, and with no second-growth timber allowed. These blocks were placed in an air-tight cylinder, and the dry heat was raised to 215 degrees Fahr., without pressure, for one hour, for the purpose of expelling moisture. The heat was then increased, pressure was applied, and the degree of both was raised gradually, in order to avoid injury to the fiber, during a period of two hours, until the heat had reached 285 degrees, and the pressure about 90 pounds, both being held at that point for one hour. The heat was then shut off, and the tanks allowed to cool gradually for one hour. At the end of this time heat had been reduced to 250 degrees, and pressure to about 40 pounds. The pressure was then blown off and the heat still further reduced. Vacuum was then applied until about 26 inches was reached; and while under vacuum the creo-resinate mixture was run into the cylinders at a temperature of from 175 to 200 degrees, and hydraulic pressure was applied, reaching 200 pounds per square inch, and kept at this point until from 21 to 22 pounds of the mixture per cubic foot had been absorbed. The liquid was then run off, and the wood placed in another cylinder, and milk-of-lime, at a temperature of 150 degrees, was run in, and hydraulic pressure of about 200 pounds was applied for one hour.

The blocks were laid, with the grain vertical, upon a foundation consisting of American-cement concrete 6 inches in depth, with a 1-inch cushion of clean, screened sand, and were driven tightly together at every sixth row. The joints were then filled with dry, screened sand, and the pavement rolled with a 5-ton steam roller until the blocks presented a firm, uniform and unyielding surface. The joints were then filled with a creo-resinate mixture of road-pitch, heated to 300 degrees Fahr., and the whole covered temporarily with ¼-inch dressing of clean, screened sharp sand.

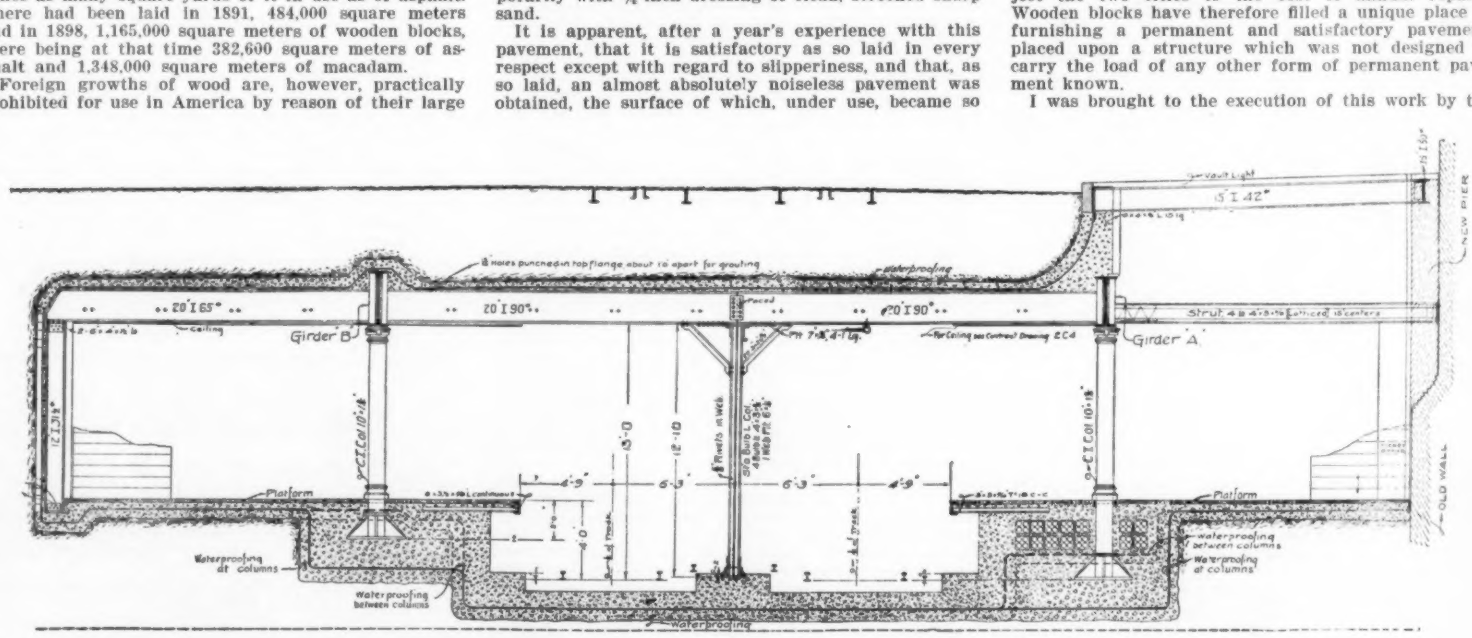
It is apparent, after a year's experience with this pavement, that it is satisfactory as so laid in every respect except with regard to slipperiness, and that, as so laid, an almost absolutely noiseless pavement was obtained, the surface of which, under use, became so unified that the joints were indistinguishable, and the pavement consequently slippery. No wear has yet been apparent. The surface remains perfect, and, in comparison with the asphalt adjoining it, is preferable in all respects, except that of slipperiness, in which, practically, it does not differ; and, upon the grade of 4 per cent at which it was laid, it has nothing to recommend it in this respect.

I have this year laid an area of 7,940 square yards upon a level street in the same manner as above described, which I believe will be eminently satisfactory in every respect, and am about to lay, this fall, another area of 6,640 square yards upon a nearly level street, where I expect the same results; but the problem of a noiseless, non-slippery and permanent pavement, which can be laid upon grades exceeding 2 per cent., has not yet been satisfactorily solved. With the hope of more satisfactory results in this respect, however, I have laid upon a 3 per cent grade an area of 2,000 square yards of wooden blocks, so recently put down as not to permit me to make any statement of the results obtained. This was laid from blocks prepared as above mentioned, differing only in shape and in the character of the joint. From each of the blocks, 4 inches by 4 inches by 8 inches, there was removed from one side, at the top, a section ¼ inch in thickness for the length of the block, and 1½ inches in depth. When these blocks were laid as above described, and driven closely, there was a ¼-inch opening, or joint, remaining, extending clear across the street with each width of block. These joints were filled with Portland cement grout. It is my expectation that this material upon the surface of the street every 4 inches will remove the slippery conditions which would otherwise exist, and furnish better foothold for horses.

There is in my charge, as commissioner having the care, with a representative of the adjoining city of Cambridge, of those bridges crossing the Charles River and connecting the two municipalities, a bridge, called Harvard Bridge, having a roadway area of 11,425 square yards. This bridge was built in 1891, within an insufficient appropriation, and in a manner which has proved to be a falsely economical one. In order to diminish the cost, the structure was lightened, and designed only to carry a wooden floor of 4-inch deck and 2-inch sheathing. Traffic upon this bridge has rapidly increased, and it has been necessary for some years to resheathe it annually; and it has now become apparent that two resheathings each year will only suffice. As the deck of the structure now shows signs of decay, it has been decided to redeck this entire structure with a hard-pine deck, treated by the same creo-resinate process as are the blocks, and directly upon this the wooden-block pavement will be laid, closely driven, and without joints, and a contract for this work is now being executed by the United States Wood Preserving Company, of New York, which controls the creo-resinate process. What has for years had many of the characteristics of an uneven corduroy roadway, caused by the rapid wearing of the sheathing-plank will soon present an even, noiseless, smoothly-riding surface, which will not subject the two cities to the cost of annual repairs. Wooden blocks have therefore filled a unique place in furnishing a permanent and satisfactory pavement, placed upon a structure which was not designed to carry the load of any other form of permanent pavement known.

I was brought to the execution of this work by the experience of the city of Chicago in laying a wooden pavement—treated, however, by another process—upon the Rush Street Bridge, which carried a large part of the freight traffic of an important railroad terminal, and which had required, therefore, many renewals annually of the wooden wearing surface of plank. This pavement had been laid over two years and a half, I think, when I last saw it, and was still apparently in first class condition. Wooden pavement has, therefore, it seems to me, a field peculiarly its own in replacing the plank surface of bridges in an economical and satisfactory manner.

The only question, aside from the desirability of laying such pavement upon steep grades, which I have already referred to, and which has not yet been sat-



CROSS-SECTION THROUGH RECTOR STREET STATION, RAPID TRANSIT SUBWAY.

* From a paper presented to the American Society of Municipal Improvements by Mr. B. T. Wheeler, ex-Superintendent of Streets, Boston, Mass.

isfactorily demonstrated, is then one of durability, which time alone can determine; but the company which has laid this pavement has, for the protection of the city which I represent, given a good and sufficient guaranty to keep the same in conditioni satisfactory to the superintendent of streets for a period of ten years.

THE ANIMAL WORSHIP OF ANCIENT TIMES.

EGYPTIAN animal mummies are popularly supposed to include only the embalmed bodies of the crocodile, the ibis and the cat, and that only animals which were either harmful or of great service were thus made the subject of a special cult. As a matter of fact, the Egyptians honored many other animals in like manner. In every province and its capital some creature was the object of veneration. In many cities, particularly in Esneh, the Nile perch (*Lates niloticus*) was worshiped, a fish still found in abundance in upper and middle Egypt. From this peculiar veneration of the Nile perch, the city of Esneh, during the Graeco-Roman period, received the name Latopolis. At the instigation of Lortet and Hugounenq, Director Maspero of the museum of Egyptian antiquities, has made excavations at Esneh and discovered innumerable Nile perch mummies, buried in shallow graves, which mummies were found not only in the burying places of the city's inhabitants, but also in the western portion of the city to the very foothills of the Libyan mountains.

These fish mummies were prepared with the same care as those of other sacred animals. They were swathed in linen. Even in the time of the Ptolemies and the Romans fishes were buried with human remains. In all sizes and of all ages were the fish found by Maspero. Some were only a few inches long; others measured five feet from nose to tail. Indeed, sometimes the newly hatched were found side by side with the full grown, wrapped in peculiarly woven rush balls about the size of two fists. Frequently several hundred newly hatched perch are contained in a single rush ball. In many of these woven sarcophagi only the large scales of Nile perches were contained—evidently an act of piety performed by the poor who were able to procure only the offals.

All the fish which have been brought to light were found to be in a most wonderful state of preservation. We are assured that many of them seemed as fresh as the day when they were pulled out of the water; the scales are still bright, and even shimmer with the chatoyant colors of life. In some specimens the eye is so well preserved that the gold and silver sheen of the retina can still be seen. All fish of fairly large size were slit on one side. Doubtless this slit served the purpose of permitting the embalming fluid to find its way to the interior, a process which has resulted in preserving the fish from decay for centuries and centuries. Not a trace of asphalt, which is usually found in the mummies of vertebrate animals, could be detected in the embalmed bodies. The chemical analysis made by Hugounenq showed traces of the salts of the Egyptian natron or soda lake in which the fish were laid until they were impregnated with salt. After they had been thus salted, the fish were wrapped in the clayey soils of the shores of these lakes. Bandages held the caked slime in place. Thus it was possible to preserve the fish in the dry Egyptian atmosphere for twenty-five centuries.

It is highly probable that this method of embalming was taught to the Egyptians by nature herself. Doubtless many animals were found well-preserved by the conserving ooze of the soda lakes. It seems, however, that a certain quantity of ordinary salt (sodium chloride) and sand were mixed by the Egyptians with the mud of the shore; for the dried bodies were impregnated with alkali salts. Sodium chloride, for example, was found present to the amount of thirty-five per cent. It seems as if human bodies were sometimes subjected to a similar embalming process, for according to ancient writers, poor people who could not afford the complicated process of spice embalming, simply pickled their dead. Only in a land where the air is particularly dry could a body be thus preserved indefinitely.

The Nile perch was one of those fishes which were not regarded as sacred throughout Egypt, but only in a particular province. For that reason it is a rather easy matter to ascertain why certain creatures should be regarded as sacred by the different Egyptian races. There were a number of animals which were worshiped throughout Egypt. According to Strabo these were, the bull, dog, and cat, the hawk and ibis, the scaly fish (*Lepidotus*) and the *Chelmon* (*oxyrhynchus*) of the Nile. The reason for this general veneration is to be found in the usefulness of the animals mentioned to man. The cat was worshiped for her mouse-catching propensities, for rats in Egypt were dreaded as the distributors of plagues. The sacredness of the fishes enumerated, depended not so much upon the service rendered by them to man, as upon a certain holy horror which the Egyptians felt for them. The Egyptians believed that the scaly fish and the Chelmon and likewise the Phagrus ate the body of Osiris when he was thrown into the Nile. The three fish mentioned were therefore considered unclean. No doubt the aversion from the Chelmon (*Mormyrus oxyrhynchus*) was caused by reason of the resemblance of its head to that of a pig, which played so discreditable a part in the myth of Osiris-Adonis-Atys. Aelianus relates that in many parts a whole catch of fish was thrown away if a single Chelmon was found among them.

On the other hand the Oxyrhynchus was made the subject of a local cult in another part of Egypt, as Grenfell and Hunt discovered some years ago. A special temple had been erected to this peculiar fish in the city bearing its name. Many amulets were found which were nothing more nor less than bronze simulacra of the fish, with the attributes of the goddess Hathor on the head. It may be that this cult, once localized, spread over the land.

Even Herodotus wondered why it was that an animal sacred in one particular province should be pursued and eaten in another. In certain cities, especially in Thebes, Aelianus and Maximum Tyrius relate that mothers considered their children fortunate if they were eaten by the crocodile, for they had passed into the body of their godhead. On the other hand, the inhabitants of Elephantine ate crocodiles and those of Apollopolis caught them in nets, suspended them from the Persea tree, scourged them unmercifully until they wept, then slaughtered and ate them. Plutarch states that it was the sacred duty of every citizen of Apollopolis to eat crocodile meat on a certain day, because Typhon, the slayer of Osiris, had eluded Horus by transforming himself into a crocodile. Strabo, who saw the sacred crocodiles of Arsinoe fed with roasted meat, honey and cakes, narrates with an astonishment equal to that of Herod that in the neighboring provinces of Herakleopolis the ichneumon, the deadly enemy of the crocodile, was worshiped. Continuing he tells us that the inhabitants of the city of Sais worshiped sheep; those of Lykopolis, the wolf; those of Hermopolis, the dog and ape; those of Memphis the baboon; the Thebans the eagle; the people of Leontapolis the lion; the people of Mendesiea the goat, and those of Athribite the shrew mouse.

Even in ancient times the worship of animals accompanied by a highly developed religion aroused general astonishment.

Many reasons were given for this strange cult; and of these reasons Plutarch in his "Isis and Osiris" has given a symposium. By some it was said that the Egyptian gods, fearful of Typhon, had transformed themselves into animals. Others declared that the chieftains of many tribes wore gold and silver animal masks in battle, in order to frighten their enemies. By some it is held that this worship of animals has its origin in metempsychosis or in the belief that certain animals were inhabited by the souls of dead ancestors. There may be a grain of truth in that assumption, for to this very day crocodiles and tigers are considered sacred in certain parts of India and the Sunda Islands. Certain North Asiatic races consider the bear their grandfather, beg him to forgive their killing him, and attribute his death to an accident. The wearwolf superstition of northeastern Europe belongs to the same category and corresponds to the African belief of the transmigration of human souls into hyenas.

A more plausible theory is that which connects the animal worship of ancient Egypt and Indians with totemism, which is rooted in the belief that by vowing not to kill a certain animal a band of friendship is sealed with the entire race, and that the assistance of these animals can always be called upon. Such a belief can be traced back to time immemorial and seems originally to have been prevalent in all parts of the world. It is found even in the old Indian traditions of the flood, in which man befriends a fish that later announces the coming of the flood and saves him. In the Persian mythology the belief occurs again. To this very day it is preserved even among civilized nations in countless fairy tales, all of which have one characteristic, namely, that a child, man or woman, by reason of some friendly act to a mouse, serpent, bird or mammal, enjoys the protection and help of all of the animals of the same family.

Catlin and Falitan find among the races of North America a veneration for animals very similar to that which prevailed in ancient Egypt. When a young Indian reached the age of manhood, he left his tribe for a certain time in order to pass days or weeks in solitude. He fasted or performed other religious rites. The first animal which appeared to him either asleep or waking, he selected as his peculiar protecting spirit (totem). A solemn vow was taken never to hunt that animal or to even injure it. Sometimes the entire family and often a tribe venerated the totem animal of an ancestor as the totem of the tribe. Even the name of this totem animal was taken by the tribe. When the worship of animals became of such importance it soon became possible to believe that the souls of tribal forefathers animated the bodies of the totem animals. Since the totem animal affected either the individual or his tribe, it follows that the totem animals of other tribes were not held sacred.

Among the Indians of North America the eagle, the wolf, the bear, the beaver and the turtle are constantly recurring sacred tribe animals. The prevailing law of exogany forbade men and women of the same tribe from marrying each other. In other words a whale could not marry a wolf. A similar custom prevails in the Samoan Islands. Among the Jakutes of North Asia, the Khonds, the Kohls of Nagpor, the Oraons, and other races of India, according to Leslie, Campbell, Dalton or others, it often happens that bears, falcons, hawks, eels and other fish and tribal animals may not be killed or eaten by the members of the tribe. Sir G. Grey states that in Australia not only animals but even plants are selected as the protectors and namesakes of tribes. The scarcity of meat, however, has been the cause of a relaxation of the law of immunity. The tribal animal is killed only in cases of necessity and never during sleep, so that an opportunity is always given him for escape.

In Africa Livingstone, Casilis and other missionaries and travelers have noted the same customs among the tribes of the Congo, Hottentots, and Betchuans. Among these African tribes, particularly those of the south, animal names are taken from the crocodiles, fishes, apes, buffaloes, elephants and lions. Not only are the sacred animals religiously preserved from harm, but even if killed by another they are not touched. That a similar custom once prevailed in Europe is shown by Ernst Krause, in his book *Die Trojaburgen Nordeuropas*. In the great group of Italian, Slavic and German tales which may be collected under the general title "Tales of Grateful Animals," many an instance of animal veneration may be found. The animal selects some man as his brother or brother-in-law, gives him a hair of his body, which has but to be rubbed between the fingers or to be burnt in order to summon the protector (totem). Among the southern Slavic races the belief in animal and plant fraternity still flourishes.

A Servian song sings of a swain who pursues his fleeing sweetheart and fraternizes with some thorny bush that it may capture and hold her.

From these parallels it follows that the customs of ancient Egypt once prevailed throughout the world and are still to be found among the primitive peoples of Africa, Asia, Australia, North and South America, and that their traces may still be detected in modern Europe. The strangest part of the whole matter is that despite an advanced religion this savage belief should have been preserved among the ancient Egyptians and that the protection which, among other peoples would be attributed only to living animals, extended likewise to dead bodies.

TRADE NOTES AND RECIPES.

Protection Against Insects.—Adolf Twisselmann gives, in the Pharmaceutische Zeitung, some valuable directions for the preparation of insect protectives, which constitute a very lucrative article for the drug stores.

Protectives for People.

I.	Yellow wax	85.0
	Spermaceti	60.0
	Sweet oil	500.0
	Melt and add:	
	Boiling distilled water	150.0
	After cooling add:	
	Clove oil	2.0
	Thyme oil	3.0
	Eucalyptus oil	4.5
II.	Bay oil, pressed	100.0
	Acetic ether	12.0
	Clove oil	4.0
	Eucalyptus oil	3.0
III.	Yellow wax	75.0
	Bay oil	160.0
	Thyme oil	8.0
	Eucalyptus oil	8.0
IV.	White vaseline	120.0
	Patchouli oil	4.0
	Valerian oil	3.0
V.	Rectified spirit of wine	130.0
	Thymol	10.0
	Eucalyptus oil	5.0
	Marjoram oil	3.0
VI.	Toilet water against insects	
	Cloves	20.0
	Patchouli herbs	12.0
	Rosemary leaves	10.0
	Valerian roots	8.0
	Diluted spirit of wine	200.0

Extract, press off and filter. A little of this tincture is added to the wash water.

Protectives from Insects for Animals.

I.	Bay oil	500.0
	Naphthalin	100.0
	Camphor	60.0
	Animal oil	25.0
II.	Bay oil, pressed	400.0
	Naphthalin	100.0
	Crude carbolic acid	10.0
III.	Lard	450.0
	Ceresin	300.0
	Bay oil	800.0
	Camphor	80.0
	Naphthalin	80.0
	Rosemary oil	25.0
IV.	Lard	600.0
	Ceresin	600.0
	Tallow	300.0
	Bay oil	2000.0
	Naphthalin	100.0
	Rosemary oil	100.0
	Asafetida	120.0
V.	Tincture of asafetida	170.0
	Crude carbolic acid	10.0
	Acetic ether	50.0
VI.	Bay oil	100.0
	Benzol	50.0
	Clove oil	10.0
	Rosemary oil	20.0

Argent-Ruolz.—The articles which are manufactured by the Paris firm of Roulz under the name of Ruolz silver, or Argent Français, resemble pure silver perfectly in appearance, but differ from the latter in greater hardness and a much lower price. According to the quality of the objects, various alloys are employed in the factories of Ruolz silver. We give below the composition of some of the alloys as produced in the French factories:

	I.	II.	III.
Silver	33	40	20
Copper	37-42	30-40	45-55
Nickel	25-30	20-30	25-35

—Metallarbeiter, Vienna.

Cleaning of Garden Walks.—1. Gas liquor. 2. Rock salt (salt for beasts). 4. Hydrochloric acid. 4. Sulphuric acid. 5. Fresh lime milk. The gas liquor has to be poured out a few times in succession, and must not touch the tree roots and borders of the paths. This medium is cheap.

The cattle salt has likewise to be thrown out repeatedly.

The use of hydrochloric and sulphuric acids is somewhat expensive. Mix 60 liters of water with 10 kilos of unslaked lime and 1 kilo of sulphuric acid in a kettle, and sprinkle the hot or cold mixture on the walks by means of a watering pot.

If lime milk is used alone it must be fresh—1 kilo of unslaked lime in 10 liters of water.

In this connection we would mention that among the varieties of gravel, lead gravel is best adapted for garden walks, since it hinders the growth of weeds greatly.—Frick's Rundschau.

To Bronze Copper.—This process is analogous to the one practised at the Mint of Paris for bronzing medals.

Spread on the copper object a solution composed of:

Acetate or chlorhydrate of ammonia	30 parts
Sea salt	10 parts
Cream of tartar	10 parts
Acetate of copper	10 parts
Diluted acetic acid	100 parts

Let dry during 24 or 48 hours at an ordinary temperature. The surface of the metal will become covered with a series of varying tints. Brush with a waxed brush. The green portions soaked with chlorhydrate of ammonia will assume a blue coloring, those treated with carbonate will be thick and darkened.—Science Pratique.

THE NAVAL WAR-GAME.

FULL REPORT OF A "WAR" BETWEEN THE UNITED STATES AND GERMANY, NOW BEING PLAYED BY THE PORTSMOUTH (ENGLAND) NAVAL WAR-GAME SOCIETY.

[Specially and exclusively contributed to the SCIENTIFIC AMERICAN.]

[NOTE.—The Portsmouth naval war-game society, of which Admiral Sir John Hopkins, G. C. B., is the president, is an association formed for the study of problems of future naval war, tactical, strategical, constructional and general, by means of the Jane Naval War-game. Fred T. Jane, the inventor of the game, is one of the members and first founders of the society. "Wars" are one of the methods by which the association pursues its studies; and the "war" in question being one that is within the realms of actual possibility, will, we think, be followed with interest by all American readers who have a taste for such problems.]

For the sake of future reference the names of the ships engaged, the speeds, coal and coal endurances assigned to them, together with a few of the general special rules are here given.

"The area of operations will extend over the whole world. So far as possible, the German strategy is to follow the lines of probable actual strategy; that is to say, it is to be usually of an offensive nature and directed against those spots which, by reason of distance from main bases, America is least able to protect cheaply. American strategy is, at the outset, to be mainly of a defensive character. But neither side is bound to adhere to any preconceived ideas outside this general idea. The fleet available for the United States is as follows:

Name.	Speed allowed knots.	Coal, tons.	Radius allowed at full speed. Knots.
Maine	15	2,000	3,000
Missouri	15	2,000	3,000
Ohio	15	2,000	3,000
*New Jersey	16½	1,900	2,500
*Georgia	16½	1,900	2,500
Alabama	13½	1,450	2,500
Illinois	13½	1,450	2,500
Wisconsin	13½	1,450	2,500
Kearsarge	13½	1,200	2,000
Kentucky	13½	1,200	2,000
Iowa	13½	1,800	2,500
Indiana	13½	1,800	2,500
Oregon	13½	1,800	2,500
Massachusetts	13½	1,800	2,500
Texas	12	1,[illegible]00	2,500
Puritan	9	600	1,000
Monterey	10½	600	1,000
Arkansas	9	400	800
Nevada	9	400	800
Florida	9	400	800
Wyoming	9	400	800
Miantonomoh	9	300	700
Terror	9	300	700
Amphitrite	9	300	700
Monadnock	10½	300	700
*California	21	2,000	2,000
*Colorado	21	2,000	2,000
Brooklyn	18	1,700	2,500
New York	18	1,200	2,000
Olympia	18	1,200	2,000
Columbia	21	2,400	2,000
Minneapolis	21	2,400	2,000
Albany	19½	700	1,000
New Orleans	19½	700	1,000
Newark	16½	800	1,500
San Francisco	16½	800	1,500
Chicago	16½	900	2,000
Baltimore	16½	900	2,000
Philadelphia	16½	1,100	2,000
Raleigh	18	600	1,500
Cincinnati	18	600	1,500
Atlanta	12	500	1,500
Boston	12	500	1,500
*Chattanooga	15	700	2,000
*Denver	15	700	2,000
*Cleveland	15	700	2,000
*Des Moines	15	700	2,000
*Galveston	15	700	2,000
*Tacoma	15	700	2,000
Detroit	16½	450	1,200
Montgomery	16½	450	1,200
Marblehead	16½	450	1,200
Katahdin	18	200	500
17 gunboats, etc	9	400	1,000
20 destroyers	27	(see below)	
24 torpedo boats	24	(see below)	
8 submarines	9	these may stay out for 24 hours	

* Ships thus marked are only available in the event of a very long war.

"Destroyers at full speed may stay out 24 hours. At 21 knots, with right to increase to full speed at 2 hours' notice, they may stay out for 48 hours. At 18 knots, with power to increase 1 knot per hour for a short time only, they may stay out for 72 hours. Their assigned speeds are always liable to be heavily reduced for weather. Torpedo boats at full speed may stay out 15 hours; at 6 knots less, with right to increase to full in one hour, they may stay out 36 hours.

"The gunboats, should they meet any cruiser, will be held captured. Should they encounter any vessels of their own type, the action will be decided by a toss-up. The same system will be employed when individual torpedo craft meet; but should divisions encounter each other, then the battle will be fought out in the ordinary way, so that tactical evolutions will decide the issue.

"The coal supplies allotted to the various large ships are approximately correct only. The approximation is made for the sake of simplicity, and the same applies to endurances at full speed. Both sides have been equally treated in this respect. Should any ship or squadron desire to proceed at economical speed, it will be allowed. As it is difficult to obtain reliable data in all cases, a general rule will have to be followed, which, for the sake of avoiding unnecessary complication, will be as follows: Ships proceeding at 10 knots may go double the full-speed distance. As this rule applies to both sides, the approximation is sufficiently correct to cover probabilities. The nominal 10-knot radii of warships are in practically all cases purely theoretical performances; and it may be noted that the radii allowed for this game, if small, are still probably over rather than under the actual.

"For coaling ship there will be a fixed time limit of 100 tons per hour. As cases may arise in which cruisers wish to take partial supplies only, all ships will be allowed to do this; but their bunker-cards,* and the corresponding radii, must be duly corrected to meet the case. No ship will, however, be allowed to spend less than *six* hours coaling, even though she needs less than 600 tons. This rule is made in order that the time allowance of getting alongside and casting off collier shall be properly provided for. By this means a fair general average speed of coaling is arrived at.

"The German fleet, which will be under exactly the same general rules as the American one, is as follows:

Name.	Speed Knots.	Coal (Maximum) Tons.	Full Speed Radius. Knots.
Wittlesbach	15	1,000	1,500
Wettin	15	1,000	1,500
Zaehringen	15	1,000	1,500
*Mecklenburg	15	1,000	1,500
*Schwaben	15	1,000	1,500
Kaiser Friedrich	15	1,000	1,500
Kaiser Wilhelm	15	1,000	1,500
Kaiser Karl	15	1,000	1,500
Kaiser Barbarossa	15	1,000	1,500
Kaiser Wilhelm der Grosse	15	1,000	1,500
* "H"	16½	1,000	1,500
* "J"	16½	1,000	1,500
Brandenburg	12	800	1,200
Woerth	12	800	1,200
†Kaiser Friedrich Wilhelm	12	800	1,200
Weissembourg	12	800	1,200
Baden	13½	600	1,000
Sachsen	13½	600	1,000
Bayern	13½	600	1,000
Wurttemburg	13½	600	1,000
Aegir	13½	500	1,500
Ooin	13½	500	1,500
Hagen	13½	500	1,500
Hildebrand	13½	500	1,500
Frithjof	13½	500	1,500
Beowulf	13½	500	1,500
Siegfried	13½	500	1,500
Oldenburg	9	250	1,000
Fuerst Bismarck	18	1,100	1,800
Prinz Heinrich	18	1,500	2,300
*Prinz Adalbert	19½	1,500	1,800
*Prinz Friedrich Karl	19½	1,500	1,800
Hertha	18	950	2,000
Hansa	18	950	2,000
Victoria Luise	18	950	2,000
Freya	18	950	2,000
Vineta	18	950	2,000
Kaiserin Augusta	18	900	1,500
Gefion	18	950	2,500
*Frauenlob	21	700	2,000
*Arcona	21	700	2,000
* "J"	21	700	2,000
Gazelle	19½	500	1,000
Nymphe	19½	500	1,000
Niobe	19½	500	1,000
Ariadne	21	500	800
Thetis	21	500	800
Amazone	21	500	800
Medusa	21	500	800
Irene	15	900	1,400
Prinz Wilhelm	15	900	1,400
Hela	19½	350	800
Meteor	18	120	700
Komet	18	120	700
20 Various	9	400	1,000
30 Destroyers	27	(Coal as for U. S. boats.)	
12 Destroyers	21	" " " "	
16 Torpedo Boats	24	" " " "	
30 Torpedo Boats	18	" " " "	

* Only available after a long period. † Presumed reconstructing.

"The general idea is that relations become strained over German action in the Philippines and in Central America. The action of England and Japan is presumed to enforce the neutrality of the other powers. On August 1, 1903, a state of "war imminent" is existing; and on this presumed date moves may begin, and either side may declare war or commence hostilities without it. Both sides are assumed to have brought their reserve ships as far forward as possible.

"All existing fortifications will be assumed to exist, but neither side may attack fortresses (other than minor ones) until it has secured command of the sea. All the important fortifications are assumed impregnable, and ships coming into range of them will be damaged on a scale to be decided by the umpires.

"Wireless telegraphy will be allowed a radius of 100 miles. All admirals must furnish the umpires with copies of their:

"a. General orders, signal codes, etc.

"b. Bunker records and ammunition supply records as kept by the players detailed for that purpose.

"c. Cruising formations, by day and by night.

"d. Scouting formations, etc.

"e. Recognition signals and the like, which may be needed in assessing the probable result of unexpected meetings by night.

"f. Any special orders, the observance of which might tend to turn the scale when delicate points have to be assessed. As an example, orders in view of a night attack by torpedo craft may be cited.

"g. Schemes for fire control.

"Not all of these, it may be observed, are essential to the game; but in each case they are calculated to render it more instructive, and to engender thought on important topics.

"As to the ships taking part, with a few alterations the fleets will be those at present in commission. A few new ships, that should be in commission by the middle of 1903, have replaced others, and destroyers have been added where a state of "war imminent" would seem to warrant it.

"Ships in commission will be as follows:

United States.	Germany.
Home.	Home.
Alabama (flag).	K. Wilhelm II. (flag).
Kearsarge.	K. Barbarossa.
Missouri.	K. Karl der Grosse.
Maine.	K. Wilhelm der Grosse.
Indiana.	Wittelsbach.
Massachusetts.	Zähringen.
Olympia.	P. Heinrich.
San Francisco.	Nymphe.
Cincinnati.	Niobe.
Detroit.	9 destroyers.
9 destroyers.	Hela.
2 torpedo-boats.	
Home. West coast.	Second Home.
Wisconsin (flag).	Baden (flag).
Oregon.	Wurtemburg.
Philadelphia.	Hildebrand.
2 destroyers.	Hagen.
South Atlantic.	Heimdall.
Iowa.	Beowulf.
Atlanta.	V. Luise.
Mediterranean.	7 destroyers.
Illinois (flag).	South Atlantic.
Chicago.	Freya.
Albany.	Vineta.
1 gunboat.	
Far East.	Far East.
Kentucky (flag).	F. Bismarck (flag).
Brooklyn.	Hertha.
New York.	Hansa.
New Orleans.	Kaiserin Augusta.
Monterey.	Gazelle.
Monadnock.	1 destroyer.
Newark.	

"New ships may be brought forward as the umpires will allow. It will be assumed that the ability to hurry forward new or refitting old ships is the same for both nations; a claim for a new ship by one side will, therefore, if allowed, entitle the other side to a ship or ships of about equal displacement. In view of the impossibility of ascertaining how far forward ships will be at the assumed date of the war, this rule is regarded as likely to afford the most satisfactory approximation.

"All torpedo craft not noted as in commission may, however, be mobilized as required.

"In all matters not herein specified, in all claims, and in all questions of time to repair ships, the decision will rest with the umpires. All contingencies for which the Book of Rules or "Hints" provide will be settled as therein laid down.

"All moves are to be made by measure, and *any infringement of the rules will be regarded as an engine-room mishap.* There will be no other provision for breakdowns; so players are warned to be scrupulously correct in tactical movements."

HOW THE GAME IS PLAYED.

Some brief explanation of the general principles of the game may be welcome to those who wish to follow carefully the various movements.

Strategical moves are made by each side in 6-hour runs on charts. These moves indicate the entire course of the fleet to its destination, and may be altered only (a) by contact with the enemy, or (b) receipt of contrary orders by dispatch vessel or wireless telegraphy. Ships that at any period of the cruise desire to use their own wireless telegraphic installations are required to mark a zigzag line beside their courses. Any other ships within 100 miles are informed by the umpire that wireless is being used and made cognizant of what is telegraphed, if friends. Hostile ships are not allowed to take in the messages (ciphers being assumed).

The rival admirals having marked their courses, these are compared by the umpire at the central table, and should hostile forces approach each other within what is considered sighting distance, the ships concerned are put upon the seaboard.

The ships are accurate models, and they have to be recognized by their opponents just as they would have to be in real war. The seaboard, with which the ships are on exact scale, is divided into large squares representing 2,000 yards, and small ones of 100 yards (half a cable). Each move represents one minute of time, consequently each square traversed is a three knot difference in speed—so long as the movement is not in a diagonal direction. When ships move diagonally to the squares, a measure is employed. The turning circles of ships, of course, vary considerably; to meet this so many squares—usually two—have to be traversed from the time the helm is put over to when she has turned four points. The loss of speed entailed in turning is, of course, allowed for. For the present war, however, special cards have been issued that mark the exact circles of ships. This is necessary on account of the fact that the German ships possess a tactical advantage in this direction which is not easily reduced to the usual convention.

Each ship is maneuvered by a different player, who captains her throughout the war. The admirals, till fire is opened, are allowed to give any directions they please to their captains; after fire is opened they may transmit signals only through the umpires and at the discretion of these, and each captain has to think for himself and carry out his orders as best he can. As the umpires rarely allow anything save the simplest signals to be made in battle, the admiral who lays down his orders clearly beforehand is in much the same position as one who does so in real war.

Firing is allowed at 8,000 yards, but at this distance the damage done is always slight. The method of firing is a characteristic of the game. More than one system is employed; but as a general rule targets representing the actual ship to be attacked at various ranges and positions are used. These pictures are divided into vertical sections of 25 feet each. Hits are localized by an instrument technically known as a "striker." Either every gun of and over 4-inch is struck for at varying rates of fire, or else one strike only per move is made for the whole lot of guns, and the damage varied as the range.

In the former case a 6-inch shell-fire of one minute's duration destroys one section if unarmored, and other guns do damage *pro rata.* When armor is hit, penetration depends, as in real war, on the nature of the projectile, the range and the angle of impact; all of which are calculated semi-automatically on much the same system as that used for "All the World's Fighting Ships." (Published at the SCIENTIFIC AMERICAN Office.) The damage is scored on plans of the ships identical with those in the work mentioned above—which is the textbook of the game.

When the alternative striking method is in use (as it is when the chief issue is a tactical rather than a constructional problem) the size of the target depends, not (as in the first system) on the range, but on the combined speeds of the ship firing and the ship fired at, i. e., whether they are *relatively* stationary or shifting bearings rapidly.

By this method an average accuracy ranging from 50 per cent at 1,000 yards to 2 per cent at 8,000 is to be obtained, supposing no misses to be made by the players. As, however, hitting is uncertain, the actual average works out very close to real battle results; and realism is secured also by the differentiation of projectiles.

This necessarily brief sketch of the way in which the game is played will afford some insight into the extreme realism that is a factor all through; the claim being that every possible condition of modern war is met. Copious books of rules scale out the chances wherever this can be done, so that a uniform system of awards is secured. These "judgments" are the mean of the opinions of naval officers specially selected in all navies. Land operations are adjusted to the same scale; but the "war" under review does not contemplate proceeding further than the securing of the command of the sea by one or other belligerent sufficiently to render invasion impossible to the one and possible to the other. No doubt, however, some small raids will have to be dealt with.

(To be continued.)

* The state of coal supply of each ship is carefully kept by her player.

SELECTED FORMULÆ.

Chemical Gardens.—As real vegetation has now become scarce it will be opportune for the pharmacist seeking novelties for window display to pay some attention to chemical gardens.

A common method of forming such a garden is to cover the bottom of a suitable globe or jar with white sand to the depth of two or three inches, press endwise into this layer some long splinters of the sulphates of iron, aluminium and copper, respectively, leaving the greater part exposed, and pour over the whole a solution of silicate of sodium (commercial water glass) 1 part and water 3 parts, care being taken not to disturb the chemicals. Upon standing a week a dense growth of the silicates of the various metals will be seen in various colors and fantastic shapes. Now displace the silicate solution by clear water, through an india rubber tube, so as not to disarrange the growth.

This is a permanent chemical garden, which may be suspended by brass chains in the center of the window with a lamp behind.

The following directions for producing a curious crystal display appeared some years ago in the New England Druggist:

"Prepare a small beaker or jar full of cold saturated solution of Glauber's salt, and into the solution suspend by means of threads a kidney bean and a nonporous body, such as a marble, stone, piece of glass or other suitable material. Now cover the jar, and in a short time there will be seen radiating from the bean small crystals of sulphate of sodium, which will increase and give the bean the aspect of a sea-urchin, while the non-porous body remains untouched. The bean appears to have a special partiality for the crystals, which is due in fact to the absorption of water by the bean, but not of the salt. In this way a supersaturated solution is formed in the immediate neighborhood of the bean, and the crystals, in forming, attach themselves to its surface."

A popular form of ornamental crystallization is that obtained by immersing a zinc rod in a solution of a lead salt, thus obtaining the "lead tree." To prepare this, dissolve lead acetate in water, add a few drops of nitric acid, and then suspend the zinc rod in the solution. The lead is precipitated in large and beautiful plates until the solution is exhausted or the zinc dissolved. In this case the action is electrochemical, the first portions of the lead precipitated forming with the zinc a voltaic arrangement of sufficient power to decompose the salt.

It is said that by substituting chloride of tin for the lead salt a "tin tree" may be produced, while nitrate of silver under the same conditions would produce a "silver tree." In the latter case distilled water should be used to prevent precipitation of the silver by possible impurities contained in ordinary water.—Drug. Circ. and Chem. Gaz.

Red Stain for Wood.—

Kino	6 ounces
Magenta crystals	60 grains
Camwood	2 ounces
Alcohol	2½ pints

Mix and digest for a few days, with frequent agitation, and filter.—Drug. Cir. and Chem. Gaz.

Liquid Rouge.—Solution of carmine is used as a liquid rouge. It may be made by the appended formula:

Carmine No. 40	2 drachms
Ammonia water	½ ounce
Water	1 pint

Dissolve the carmine in the ammonia water diluted with a little water, add the remainder of the water, shake well and finally decant from any sediment that may be deposited.

The presence of the ammonia is somewhat objectionable on account of the odor and its possible action on corks if the preparation is long kept, and where a slight increase in cost and labor and the presence of glycerin is not objectionable the recipe of the National Formulary may be employed. It is as follows:

Carmine	60 grammes
Water of ammonia	350 c.c.
Glycerin	350 c.c.
Water, a sufficient quantity to make	1,000 c.c.

Triturate the carmine to a fine powder in a Wedgwood mortar, and gradually add the water of ammonia and afterward the glycerin, under constant trituration. Transfer the mixture to a porcelain capsule and heat it upon a water bath, constantly stirring, until the liquid is entirely free from ammoniacal odor. Then cool and add enough water to make 1,000 c.c.

No. 40 carmine should be used here as in the first formula.—Drug. Cir. and Chem. Gaz.

Wrinkle Remover.—

White petrolatum	7 av. ounces
Paraffin wax	½ av. ounce
Lanolin	2 av. ounces
Water	3 fl. ounces
Oil of rose	3 drops
Vanillin	2 grains
Alcohol	1 fl. drachm

Melt the paraffin, add the lanolin and petrolatum, and when these have melted pour the mixture into a warm mortar, and with constant stirring, incorporate the water. When nearly cold, add the oil and vanillin, dissolved in the alcohol.

Preparations of this kind should be rubbed into the skin vigorously, as friction assists the absorbed fat in developing the muscles, and also imparts softness and fullness to the skin.—Pharm. Era.

Photographic Mountant.—

Gum arabic	2 ounces
Glycerin	½ ounce
Alcohol	1½ ounces
Water	8 ounces

Dissolve the gum in four ounces of the water, add the glycerin, and then, with constant stirring, add alcohol. Lastly, add water sufficient to make up 8 ounces.—Pharm. Era.

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TABLE OF CONTENTS.

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PAGE
... 22551

... 22544

of
... 22552

... 22543
... 22548
... 22555

... 22549

... 22550
... 22549

. 22542

. 22547

. 22554

. 22544

22543
22556
22550
22554

22547

22548

22549